A Toolbox for Alleviating Traffic Congestion

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'Foreword

Billions of hours are wasted each year in traffic jams. Traffic jams not only impede our mobility, but they also pollute our air, waste fuel, and hamper economic growth. Traffic congestion is one of the most critical transportation issues facing us, and it is only predicted to get worse during the next 20 years. There are, however, proven techniques and strategies that we can use today to help us get beyond gridlock tomorrow.

A Toolbox for Alleviating Traffic Congestion is intended for elected officials, business and community leaders, representatives of the media, and others interested in learning more about what options are available for reducing traffic congestion and improving mobility. The Toolbox examines the causes behind the growing traffic congestion problem and describes specific actions that can be taken to improve the situation. For each action, the relative benefits and costs are also presented, along with an explanation of the methods of implementation.

For more information about alleviating traffic congestion, contact your local transportation engineering department or the Institute of Transportation Engineers.

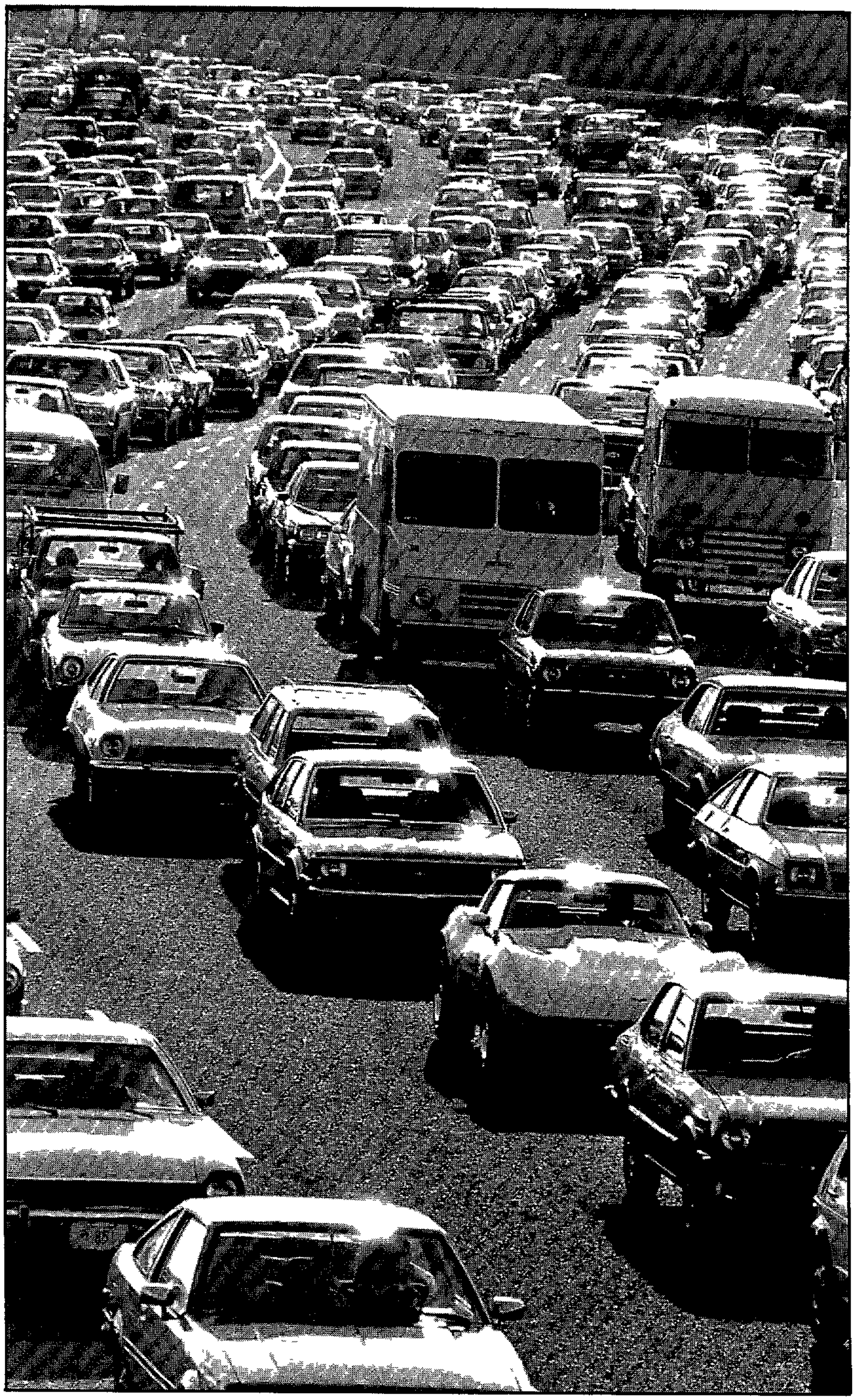


Photo courtesy of Institute of Transportation Studies, University of California, Berkeley

1 Traffic Congestion-

An overview

Over 30 years ago, the U.S. embarked upon the largest public works project in its history-the construction of the Interstate highway system. The urban portions of this system along with the highways and transit systems developed by state, county, and local governments have provided urban Americans with unprecedented levels of mobility. However, in many communities increasing levels of traffic congestion have turned once easy commutes into nightmares. And people are turning to community officials for solutions.

The purpose of this *Toolbox* is to provide local elected officials, business leaders, and community leaders with information on the congestion phenomenon and on the strategies that can be used to deal with it. There are ways of solving traffic congestion problems. Some actions can be used individually, while others require mutually supportive actions implemented by several public and private sector groups. Some actions focus exclusively on changes to the transportation system, while others deal with changes to land use development procedures. Some actions provide added capacity to highway and transit systems so that passenger demand can be accommodated, while others attempt to change the characteristics of the demand itself (e.g., by encouraging carpooling). However, no matter what type of action is considered, those who are facing traffic congestion issues need to have information on the likely effectiveness of actions under consideration, The ***Toolbox*** is organized to provide this type of information.

The remainder of this chapter discusses the characteristics of traffic congestion, its history, future trends, and impacts and costs to the community. Chapter 2 presents an overall framework for developing a coordinated program to alleviate traffic congestion. Chapter 3 discusses actions that can be implemented to enhance the person-carrying capability of our highway system, without adding significantly to the width of the highway. Chapter 4 discusses actions that result in substantial added capacity to the highway system, either through the widening of existing roads or by constructing new highways. Chapter 5 discusses public transportation actions that can be used to move people more effectively. Chapter 6 discusses actions for reducing transportation demand either through land use management or site-specific policies like carpool programs. Chapter 7 discusses funding and institutional actions that can be used by themselves or in combination with other actions. Chapters 3 through 7 are structured to provide the reader with easily accessed and understood information about specific actions. Each section presents 1) a brief description of the action with special attention given to the criteria for success, 2) the costs and benefits/impacts of the action that have been determined from previous experience, 3) steps needed to implement the action successfully, and 4) sources of further information on the action.

Why Worry?

Put simply, traffic congestion means there are more people trying to use a given transportation facility during a specific period of time than the facility can handle with what are considered to be acceptable levels of delay or inconvenience. To some, congestion is not a problem. It is considered to be one result of economic prosperity and one that we will have to learn to live with. Proponents of this viewpoint argue that our expectations about convenient travel will simply have to change. Others argue, however, that the consequences of congestion are much more serious to a community. Those holding this viewpoint have often relied on one or more of the following arguments :

Local Traffic Impacts: When faced with congested conditions, many drivers quickly look for ways to bypass the bottleneck. These often include making their way through residential neighborhoods on streets not designed to handle through traffic. uch bypass traffic often becomes the focus of neighborhood complaints. Similar complaints are often heard when overflow parking finds its way into neighborhoods.

Economic Growth: Efficient transportation access to employment and shopping sites is an important consideration to businesses and developers when considering expansion opportunities. A good transportation system is an important selling point to communities which desire to attract development. In addition, good transportation is very important to the movement of goods and services and thus has a direct impact on sound economic growth and productivity.

Community Access: Good access within a community and to other parts of the metropolitan area is an important issue to community residents. Not only is good access important to those looking for places to live, but it can become an important community public safety (e.g., police and fire) issue.

Quality-of-Life: lb some people, congested highways are a symptom of deteriorating quality-of-life in a community. In many cases, and in particular in suburban communities, residents moved to their community to escape urban problems like traffic jams. Now, facing this congestion has once again become part of their daily routine.

Highway Safety: Congested highway conditions, whether stop-and-go traffic along a major road or traffic trying to get through intersections, can often result in accidents. Reducing this congestion could reduce the number of accidents and generally produce safer travel conditions.

Environmental Quality: Congested road conditions can have a detrimental effect on the environment, in particular air quality. Making improvements to the transportation system or trying to change travel behavior has been an important objective of those wanting to improve environmental quality.

These arguments can be important reasons for not overlooking traffic congestion. However, of even more interest to community leaders, solving the congestion "problem" has become in several cases a litmus test for effective leadership. Because congestion can affect a community at large and given that the public sector is viewed as having the major responsibility for solving transportation problems, community officials are often the focal point for citizen unrest concerning traffic congestion.

Traffic Congestion: Today and Tomorrow

Increasing levels of congestion are common in urban areas throughout the U.S. Recent public hearings held in every state to determine local transportation concerns identified present and future congestion as the top problem [Ref. 1].

Washington	"Congestion on the Interstates is Seattle's number one problem."
Florida	'Over half of the roads in Florida's urban areas are congested and grow worse every year."
Washington, DC.	"The percentage of peak hour vehicle miles of travel operated under significantly congested conditions is expected to climb from 40 percent in 1980 to over 60 percent in the year 2005."
Minnesota	"The miles of congested freeways in the Minneapolis-St. Paul area is forecasted to double by the year 2005."
California	'Urban congestion is costing California $2 million a day in lost productivity. Yet traffic delays on state highways is expected to increase 174 percent by 1995."
North Carolina	"The number of congested intersections in Charlotte grew from 40 to 123 between 1980 and 1989."
New York	"In the next 20 years, traffic in the Albany area will increase 30 percent and traffic congestion 70 percent."
Idaho	"Traffic volumes will double by the year 2005."
Oregon	"Traffic congestion will increase two or three times by the year 2000."

Nationally, the congestion figures are even more staggering. According to a study by the Federal Highway Administration, delays on urban freeways are expected to increase by 360% between 1985 and 2005 in central cities and by 433% in outlying areas [Ref. 2]. This increase in congestion is not only expected to occur on urban freeways in the largest cities. Freeway delay is projected to increase by over 300% in areas of over one million population, and by over 1000% in urban areas under one million population. Non-freeway delay is projected to increase by around 200%.

How did we get into such a situation? Can an understanding of the factors that contribute to traffic congestion provide some clues on possible remedies? To examine these questions we will use the following statement as a point of departure:

> Congestion has become worse because an increasing number of people are traveling by automobile in metropolitan areas, to and from locations dispersed throughout the region, in areas where highway capacity has not been provided.

Several aspects of this statement need more detailed attention to understand fully the causes of congestion [Ref. 3].

More people traveling in metropolitan areas-Americans today predominantly live in metropolitan areas. More than 75% of the nation's population lives in such areas, with over 108 million people living in 35 areas of over one million population. Over 86% of the nation's population growth since 1950 has occurred in suburban areas. Therefore, one of the reasons for increased urban travel is that there arc more people living in urban areas.

Even more important than population growth is the dramatic increase in jobs and the increase in the number of people able to work. Employment growth since 1970 has proceeded at a rate about twice that of population growth. Between 1980 and 1987 alone, 10 million workers were added to the work force. These jobs were filled by a large number of people who reached working age (the "baby boomers") and by women, the latter entering the work force in substantial numbers. For example, of the 50 million new workers who have entered the labor force since 1950, 30 million were women. Today, women represent over 45% of the nation's labor force.

This tremendous increase in urban population and employment is one factor that explains the dramatic increase in traffic congestion.

More people traveling by car-The automobile is the predominant mode of transportation in U. S. urban areas. The increase in the number of automobiles on the road is the result of three major factors-increased number of households, increased number of automobiles available per household, and the decline of other means of transportation.

As noted previously, the U.S. has seen rapid growth in urban population over the past 30 years. However, the number of households grew even more dramatically over the same period, with the new workers entering the work-force, single parents, and elderly persons contributing to this growth. For example, between 1970 and 1980, 70 million households were created, more than twice the rate of population growth. This growth in households is important for transportation in that it is the household that determines individual (and when aggregated across all households, total) travel characteristics.

One of the important transportation-related household characteristics is vehicle availability. A majority of households now have two or more cars, and nationally the number of vehicles available has surpassed the number of licensed drivers. Most critically for transportation, the number of vehicles per worker has gone from 0.85 in 1960 to 1.34 in 1980. This factor is extremely important in explaining the propensity for the automobile-dominated work trip.

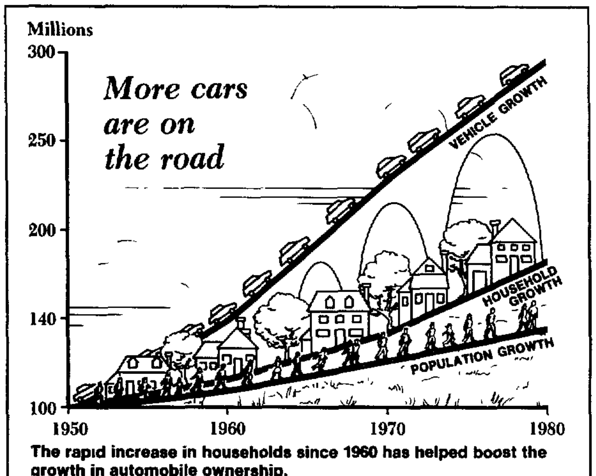
The increased availability of the automobile for travel occurred at the same time that other forms of transportation (most notably public transportation) were not providing a convenient alternative. Population and employment growth occurred predominantly in those parts of metropolitan areas where transit was weakest-the suburbs. And subsequent travel patterns, i.e., the suburb-to-suburb commute, provided little option except via the automobile.

More people traveling to and from locations dispersed throughout the region-Over 86% of the growth in national population since 1950 has occurred in suburban areas. Approximately two-thirds of all the jobs created between 1960 and 1980 were located in suburban areas. The result of this suburban growth has been an explosion in the number of suburb-to-suburb trips made in our metropolitan areas. Of the total growth in the commuting trips in the U.S. between 1960 and 1980, suburban commuting accounted for 83%. The suburb-to-suburb travel pattern nationally and in most metropolitan areas is now twice the size of the traditional suburb-to-center city travel pattern. This dispersed nature of travel origin and destination is the major cause for significant increases in traffic congestion observed on roads that primarily serve non-center city-oriented trips, e.g., beltways.

More people traveling in areas where the necessary highway capacity has not been provided-The explosive growth in suburban areas combined with severe budgetary pressures on local governments have created a situation in many cases where the highways and local streets needed to accommodate this growth have not been provided. Many governments have turned to alternative sources of funding (e.g. impact fees on developments) or have succeeded in passing special revenue measures (e.g., sales tax or bonds) to provide the necessary infrastructure. Others, however, have not been able or are unwilling to do this, or if they have, the proceeds do not meet the levels required. The result has been nationally that local expenditure on roads and highways, when adjusted for inflation, has remained relatively constant over the past decade. Even in those cases where sufficient funds have been raised, building a highway (especially if there are environmental issues associated with it) can take a very long time. In the interim, congestion levels continue to build.

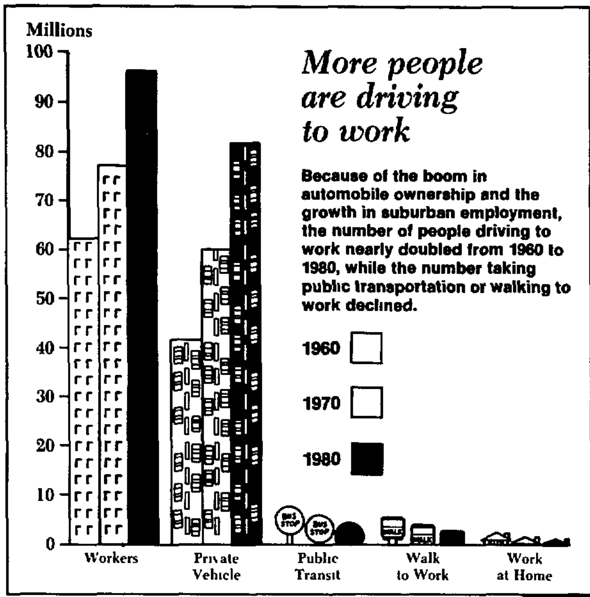
These four factors are the major contributors to increasing levels of congestion (see Figure l-l), The trends for each factor indicate that they will be even more pronounced in the future. The nation is thus facing a very serious challenge.

Figure 1-1



The rapid increase in households since 1960 has helped boost the growth in automobile ownership.

Source Alan E. Pisarski, Commuting in America



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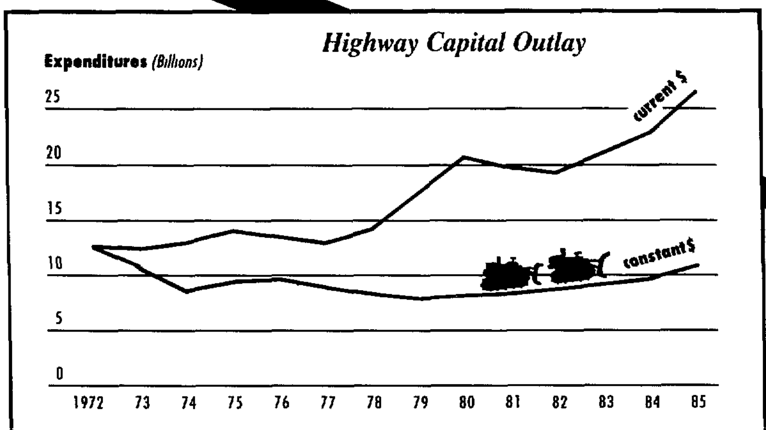
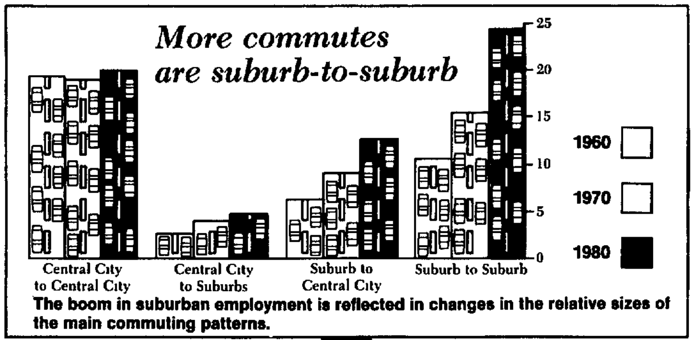
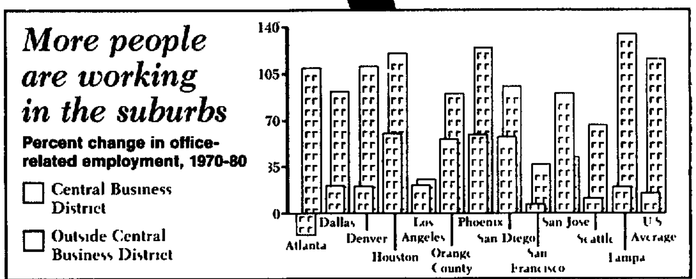


Source *Federal Highway Administration* 1987

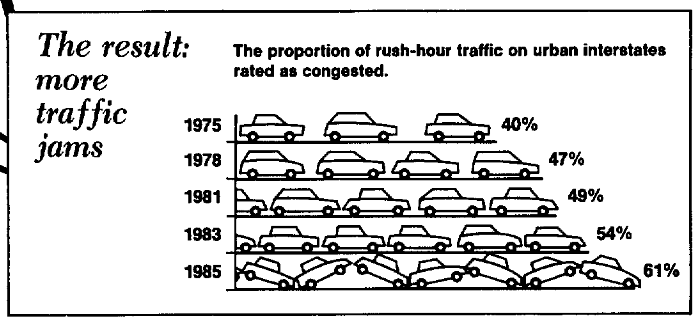
Parts of this figure were reprinted, with permission, from "Gridlock in Suburbia," by Sarah Glazer, Editorial Research Reports, June 3, 1988.



Source: Alan E. Pisarski, Commuting in America



Source: Robert Cervero, Suburban Gridlock



Source: U.S. Department of Transportation

Can Anything Be Done?

The simple answer to this question is, "yes"! There are proven techniques that can be used to alleviate today's congestion problems, as well as transportation and land use strategies that can be implemented to avoid future congestion. The more difficult answer to this question is, "Yes, but. . ." Many of these techniques and strategies require changes in individual travel behavior, persuasive use of governmental power over land use decisions, changes in institutional structure, and/or increased funding. This is particularly true for those strategies aimed at avoiding future congestion. Given this perspective, what can be done?

- Recognize that traffic congestion is often a more difficult problem than simply too many cats. There are institutional and land use dimensions to the problem that make it complex.
- Recognize the direct and fundamental relationship between land use and traffic level patterns. Approving land developments without providing adequate transportation capacity will result in congested, unsafe, and environmentally damaging conditions.
- Recognize that congestion solutions can be considered from the supply side (i.e., improvements to the transportation system), from the demand side (i.e., managing the use of the transportation system), from a land use perspective, or a combination of the above.
- Consider carefully how individual actions relate to one another and how, when combined into an overall program, they relate to regional and community objectives.
- Implement those actions that through sound engineering and planning analysis are shown to improve congestion problems in a cost effective manner. Be realistic in the assessment of what is likely to be accomplished.
- Recognize early on that the implementation of actions that are likely to be controversial will require strong commitment and efforts at developing a constituency for the action.
- Incorporate private sector interests (developers, employers, business associations, etc.) into the planning and decision-making process. Often it is in their best interest to participate, and they can provide strong support in gaining project or program adoption.
- Cooperate with neighboring jurisdictions or regional agencies in those situations where the congestion problem is an areawide phenomenon. In many cases, because of the dispersed nature of travel patterns, solutions to particular traffic congestion problems in a region or corridor will require a multi-jurisdictional approach.

Thus, there are actions that can be taken to deal with congestion issues. In many cases, however, they require a thoughtful approach on how best to implement and a realistic assessment of what is likely to be accomplished. At the very least, they take a commitment that it will be done.

References

1. "Beyond Gridlock-The Future of Mobility as the Public Sees It." Advisory Committee on Highway Policy-2020 Transportation Program, Washington, DC, 1988.
2. Federal Highway Administration, "Urban and Suburban Highway Congestion." Working Paper No. 10, Washington, DC, December, 1987.
3. See ***Commuting in America,*** by A. Pisarski, Eno Foundation, 1987, for a more detailed examination of the causes of congestion.

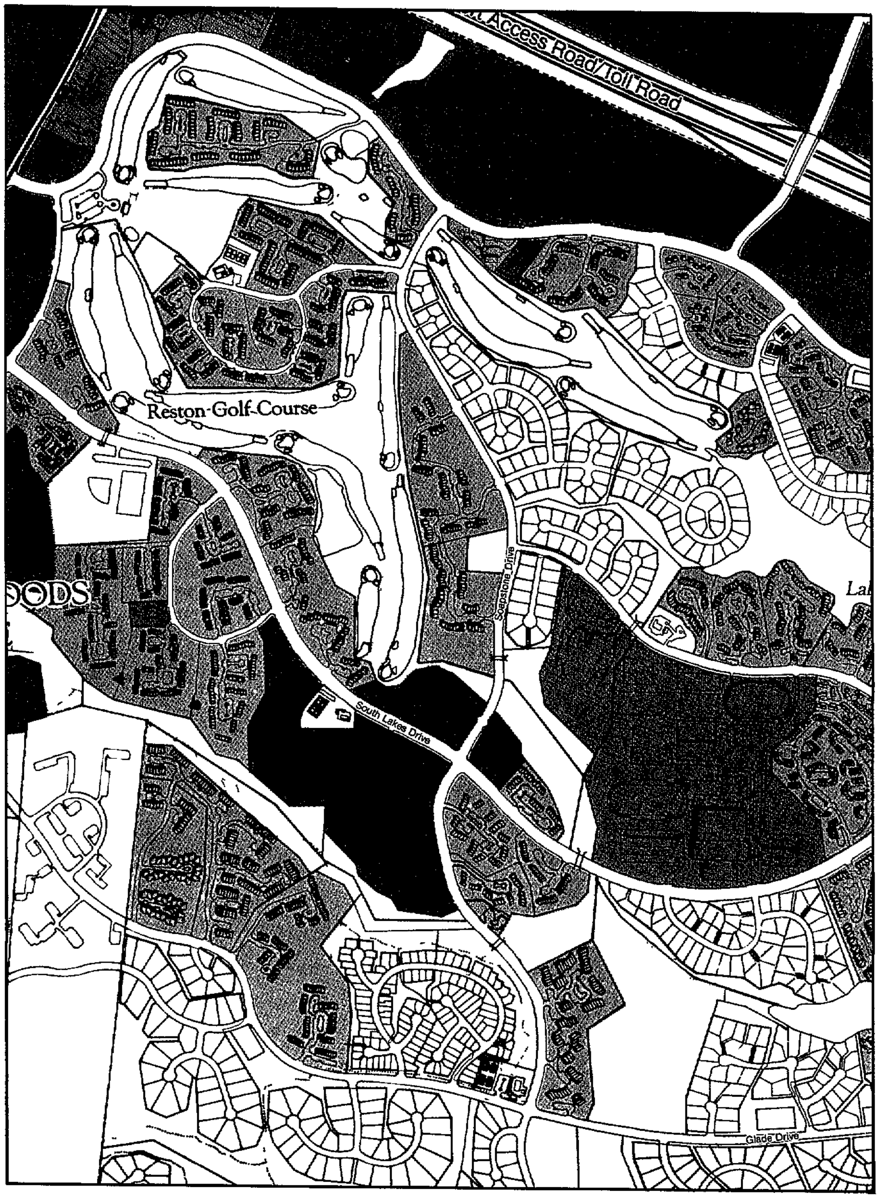


Photo courtesy of Reston Land Corporation

2 Putting, It All Together-

Development of a Coordinated Program to Alleviate Traffic Congestion

Many communities are facing congestion problems at very specific locations, e.g., intersections and entrances to major shopping centers. These problems can be addressed with several of the techniques discussed in subsequent chapters. However, much of the traffic congestion facing communities in high growth areas is caused by factors often outside the control of community officials. In addition, the long term trends in development and travel characteristics imply that no matter what action is taken to solve the immediate problems, they will simply reoccur as these trends catch up to and overwhelm the added capacity provided by the transportation improvements. In such situations, community officials need to be concerned with not only those actions needed to mitigate existing congestion, but also those actions needed to avoid future congestion.

Congestion as an Areawide Phenomenon: Development of a Coordinated Program

Although engineers, economists, and planners seem to have one or two favorite solutions to the congestion problem, there really is no single solution. As stated earlier, the congestion phenomenon is the result of demographic and market forces that are difficult to change. To be effective within this context, one needs to examine how actions complement one another and how over the long run these actions will influence future travel patterns.

A coordinated program for dealing with congestion should consist of several components. The specific structure of such a program depends, of course, upon funding and the feasibility of implementing such actions in the local political environment. First, a congestion program should provide the most cost effective transportation system improvements that reduce or alleviate traffic congestion consistent with community goals. These improvements can include physical expansion of the highway system or additional transit services, as well as operational changes to improve the performance of the existing transportation system. Second, such a program should examine better ways of managing transportation demand, especially if the opportunity for substantial gains in system performance through expansion or operational improvements is limited. Third, a congestion program should explicitly consider long-run congestion-avoidance strategies. This means that there needs to be some concern for future land use/development patterns and their impact on travel. Finally, the program needs to deal with the institutional arrangements and funding requirements for implementing the program. In most cases, some substantial level of funding will be necessary to deal effectively with congestion.

Even though these program components are listed separately, they are really complementary to one another. For example, a ridesharing program (an effort to influence demand) can become more effective if some form of preferential treatment is provided en route (e.g., a high occupancy vehicle lane) or at the destination (e.g., preferential parking), both changes to the transportation system. The effectiveness of the ridesharing program could be even greater if developments were required to incorporate enhanced ridesharing activities into their design and use (a land use/ development decision). The congestion program must therefore consider how each action complements one another.

The characteristics of each program component follows. A key word that is used to describe each component is "management ." Because much of our transportation system is in place, the decisions of what additional capacity to provide, what types of operational improvements to make, how to influence demand for the purpose of reducing the impact of traffic, how to develop compatible land use, and how to provide the institutional and funding structure that supports the program are all in essence system management decisions.

Managing Transportation System Supply-Managing the transportation system by adding new facilities or by making operational changes to improve system performance is the most common response to congestion problems. Actions such as the construction of new highways and transit facilities; the provision of improved traffic signalization schemes; the use of traffic engineering improvements such as turn lanes, one-way streets, reversible lanes, and turn prohibitions; and, ramp metering are illustrative of the types of actions that can be used to deal with congestion problems that occur every day. Increasingly, transportation professionals are also becoming interested in those actions such as incident detection programs, motorist information systems, and towing/enforcement efforts that can be used to minimize the effects of accidents and other non-recurring incidents on traffic flow.

Because planners and engineers have had more experience with managing the transportation system, there is a great deal of evidence to show what impact these actions have on reducing congestion. In the extreme, that is, where new capacity can be continually added to accommodate the demand, these actions can completely get rid of congestion. However, in heavily urbanized areas, the construction of these actions can be costly, their implementation met with strong opposition, and even if feasible, they might take a long time to complete. It is for these reasons that other actions for dealing with congestion are necessary.

Managing Transportation Demand-In its broadest sense, demand management is any action or set of actions intended to influence the intensity, timing, and spatial distribution of transportation demand for the purpose of reducing the impact of traffic. Such actions can include offering commuters one or more alternative transportation modes and/or services, providing incentives to travel on these modes or at non-congested hours, and/or incorporating growth management or traffic impact policies into local development decisions.

Available evidence suggests that well-conceived and aggressively promoted demand reduction programs can indeed decrease peak period traffic by as much as 10 to 15%. But one should be careful to understand the limitations of this technique. Demand reduction efforts, unless undertaken on a truly massive scale, can have only a local impact. They can relieve spot congestion-for example, at entrances and exits to large employment centers-but they cannot appreciably reduce traffic on freeways and major arterials. This is not to say that traffic mitigation programs are not worth undertaking. However, one should be careful not to raise unrealistic public expectations as to their impact on areawide levels of traffic congestion.

Managing Land Use-One of the fundamental relationships in understanding how and why the transportation system operates as it does is the linkage between land use and transportation. Put simply, trip-making patterns, volumes, and modal distributions are largely a function of the spatial distribution and use of land. Thus, at individual development sites, exercising control over the trip generating characteristics of the land use (e.g., development density) can be used to make the resultant demand consistent with the existing transportation infrastructure and the level of service desired. Such control is really a demand management action.

Over the long run, the spatial distribution of land use can greatly influence regional travel patterns, and in turn this land use distribution can be influenced by the level of accessibility provided by the transportation system. Avoiding future congestion therefore requires careful attention to zoning and land use plans, in coordination with the strategic provision of transportation services to influence where development occurs.

Managing the Institutional and Funding Framework-Implementation of individual congestion reduction actions or combinations of actions is often constrained by institutional problems associated with the coordination of many groups in both the public and private sectors. The authority for transportation decision making is dispersed among several levels of government and often between several agencies within each governmental level. The areawide nature of congestion requires a regional or subregional framework of decision making. In some metropolitan areas, the challenge created by today's transportation problems has resulted in transportation agencies re-examining their mission and function. For example, many transit agencies are responding to the new, non-traditional suburban markets with new types of services. Transit agencies are viewing themselves as "managers of mobility" rather than just operators of traditional bus or rail services. In other metropolitan areas, subregional planning groups have been formed to deal with the transportation problems in their communities. In some cases, proposals have been made to create a regional transportation authority with the responsibility of speeding up decisions. As stated in a recent report which recommended such astructure in one U.S. city, "the. . . area confronts a policy implementation gridlock. . .with too many agencies working at cross purposes on too many potential projects and not enough funds in place to follow through with the key projects" [Ref. 1]. Such a description fits the situation in many U.S. cities.

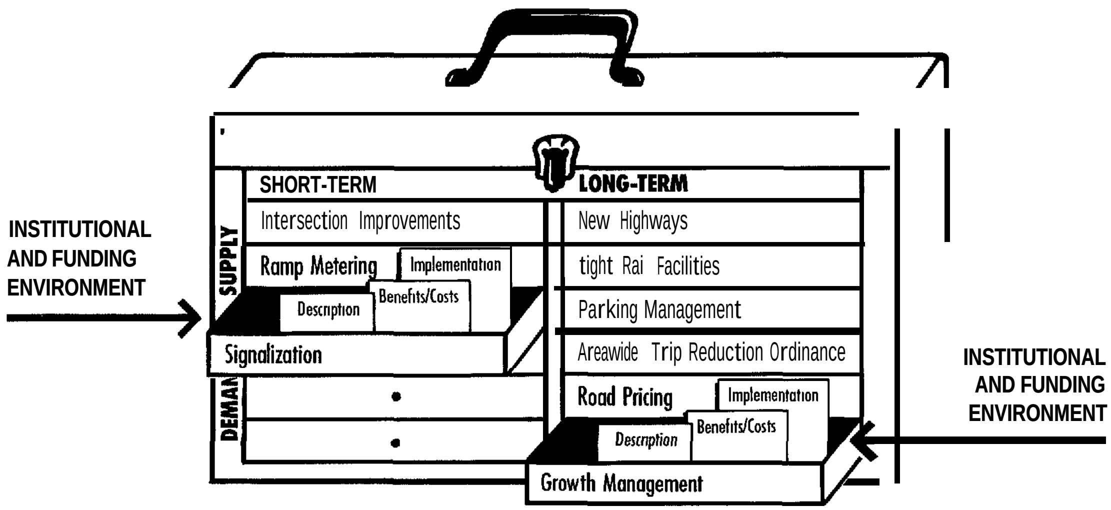
The increased role of the private sector in dealing with transportation issues has often introduced added complexity into the institutional structure for decision making. Diverse perspectives on responsibility, funding, and decision-making authority, combined with differing expectations of project timing and outcomes, can lead to frustration in dealings between the two sectors. It seems clear, however, that the effective handling of congestion problems requires the active participation and support of private sector groups. Therefore, successful implementation of congestion reduction actions will be in large part due to the success that project proponents have in managing the institutional characteristics of decision-making and project implementation in the public sector and between public and private sector participants.

Adequate funding is an important aspect of any congestion reduction action or program. In those cases where actions are more local and site-specific, acquiring the necessary funding will be a matter of programming the project in the capital budget of the responsible agency or of getting commitments from other sources (e.g., developers or business associations). At the regional level, adequate funding for congestion reduction programs could require special assessments or taxes that would be allocated for this purpose. Such funding will most likely require serious political deliberation and voter approval. Given that not much can happen without funding, managing the process of obtaining the required resources and then effectively managing the operating and capital budgets that result is the most critical aspect of a comprehensive congestion reduction program.

A Congestion Reduction **Toolbox**

All of the congestion reduction actions that are presented in the rest of this ***Toolbox*** and which fit into the categories discussed in the previous section can be considered "tools" that can be used to deal with congestion problems. Similar in concept to the tools that are used to make repairs around the house, these tools, both individually and in different combinations, can be used to "fix" congestion problems [Ref. 2]. For purposes of presentation, assume that these tools are available in a toolbox. As shown in Figure 2-1, this toolbox has four different compartments. In some cases, the nature of the congestion problem would require tools that deal with changes to transportation supply and which require a short (1 to 3 years) timeframe to implement. Other drawers in the toolbox contain tools that also deal with transportation supply but which require a longer implementation framework, as well as tools that try to influence transportation demand over both short and long timeframes.

Figure 2-1 Congestion Reduction Toolbox



The remaining chapters of this book provide the contents of these drawers. Figure 2-l is also an example of how this toolbox (and the remainder of this book) can be used. Note that each drawer contains information on that particular congestion reduction action, its benefits and costs, and the requirements for successful implementation. Once a drawer is opened the effectiveness of that particular congestion reduction tool depends on the institutional and funding environment specific to that tool. The challenge to the user of the toolbox of course is to know which tool or combination of tools to use in a particular situation. A screwdriver and wrench are often necessary to tighten a bolt. Solving a congestion problem may similarly require some combination of highway improvements and development policies (e.g. reduced density levels for new sites) in a specific corridor. In fact, as noted previously, the areawide nature of congestion will usually require some combination of sections. What is needed then is a better understanding of the benefits and costs of each congestion reduction tool available to community officials and the effect that these tools have when combined into packages.

Information on the impact, cost, and implementation timeframe for each congestion reduction tool would be of use to community officials. This information would provide useful guidance on what to expect from the congestion reduction tools that are available. Chapter 8 presents completed matrices with information provided from Chapters 3 through 7. Although the matrices are useful for determining the likely consequences of individual and combined congestion reduction tools, the specific characteristics of the congestion problem and the institutional/funding framework for using those tools will have a significant effect on ultimate success or failure.

Commitment **and** Process

Tools are not very helpful to a handyman if he doesn't know how, or if he is unwilling, to use them. The same can be said for the congestion reduction tools. Many of the congestion reduction actions, especially those that attempt to influence demand, require time for their effects to occur. For example, a major purpose of preferential lanes for high occupancy vehicles on major freeways is to encourage the increased use of transit and ridesharing. For this to happen in any significant way might have to await land use and travel behavior changes that could take years. In the meantime, inconvenience to existing users of the freeway could result in political pressure to remove the lane. Officials must have a strong commitment to the implementation of these types of techniques if they are ever to be effective.

One of the ways of gaining support for these actions is to involve the public in the discussion and debate that precedes adoption. Some of the most successful efforts at adopting congestion reduction programs have exhibited the following characteristics:

- Waging an aggressive campaign to inform the public of what is likely to occur if something is not done.
- Clearly stating what the average citizen will gain from these actions.
- Providing opportunities for concerned citizens and interest groups to participate in the planning and decision-making process.
- Actively pursuing business support for the proposed actions.
- Seeking media support in editorials and news reporting.
- Developing a cost effective program that appeals to as broad a political base as possible.

There are many examples from around the country where good ideas and projects have languished for years. In some sense then, the process of implementing congestion reduction actions is as important as the actions themselves.

References

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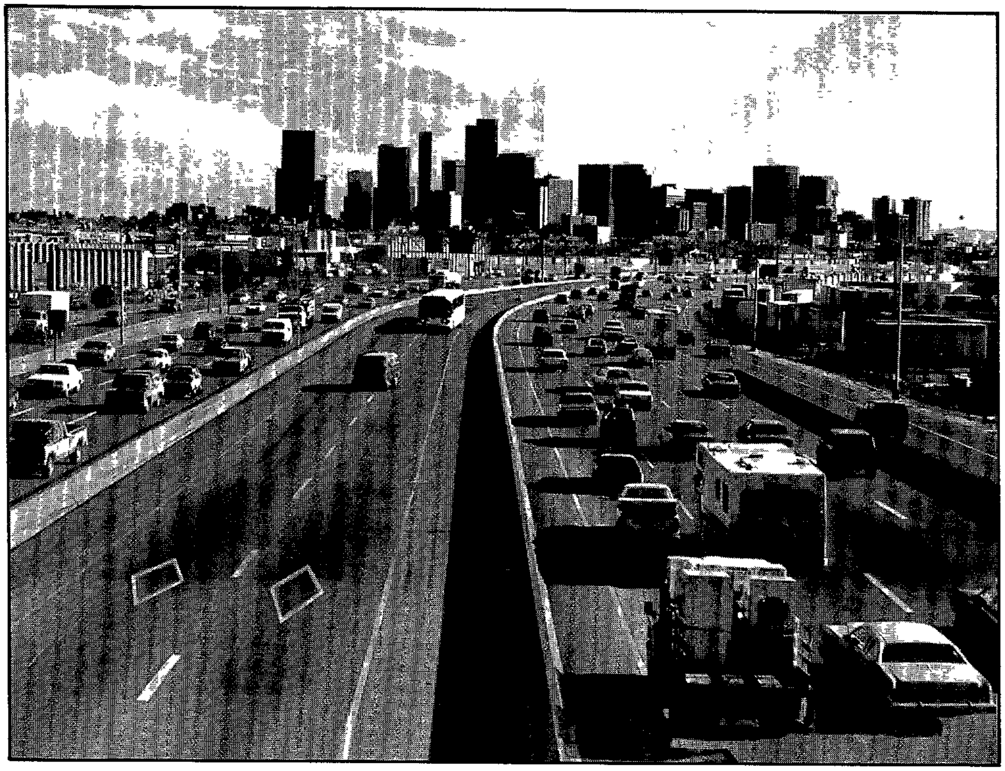
2. The concept of a congestion "toolbox" is based on ideas developed by Stephen C. Lockwood in "Kaleidoscope or Map: Suburban Congestion and Institutional Barriers," Transportation Research Board, 1988.

Notes



3 Highways-

Getting the Most Out of the Existing System

This chapter is organized in two major sections-the first focusing on actions primarily oriented to urban freeways or expressways, and the second oriented to arterial and local streets. The last section in the chapter discusses the important role of enforcement.

As indicated in Chapter 1, highway congestion will grow substantially worse by the year 2000 if improvements to existing roadways are not made. In many cities, these improvements will include the construction of new highways. However, in these and other cities, local officials will be greatly interested in what improvements to the existing highway system can be made before more costly and potentially more disruptive highway construction occurs. This chapter discusses the cost effective improvements that can be made to existing freeways and arterials in as short a period of time as possible.

Urban Freeways

Although urban freeways make up less than 3 % of the total urban highway mileage, they carry approximately 30% of the traffic nationwide. Thus, the large percentage of vehicle-miles traveled (VMT) carried by urban freeways makes the traffic conditions on these freeways a good indicator of areawide travel quality.

Freeway congestion can occur under recurring conditions (i.e., due to capacity or operational problems) or can be caused by accidents or break-downs, known as non-recurring congestion. By some estimates, as much as 60% of all freeway congestion is considered to be non-recurring. The approaches discussed in the following sections will describe the potential of reducing one or both types of congestion.

ACTION: Freeway Incident Detection and Management Systems [Refs. l-4]

DESCRIPTION: A freeway incident detection and management system consists of one or some combination of: roving tow or service vehicles, motorist aid call boxes, citizen band radios and cellular phones, incident teams, detectors in mainline lanes to monitor volume, ramp metering devices, motorist information systems, traffic diversion, and alternate route identification. The surveillance system itself normally consists of highway and ramp traffic detectors, changeable message signs, closed circuit television surveillance on particular trouble spots, a communications system, and some type of central computer control. A system of detectors connected to the central computer allows monitoring of conditions throughout the freeway system. Pertinent driver information is provided through the changeable message sign system and radio traffic reports (and in some cases, highway advisory radio) to alert drivers to congested conditions and allow diversion to alternate routes if necessary.

BENEFITS/COSTS: Through the use of a freeway incident detection and management system, incident duration can be reduced by an average of 10 minutes. A 1986 Federal Highway Administration study [Ref. 5] revealed that such a system could reduce congestion on approximately 30 percent of the major urban area freeway mileage, returning a benefit/cost ratio of approximately 4:1, where benefits are measured as the aggregate value of time saved by the motorists. Current costs per mile for an average system are about $1 million to design and construct and $100,000 per year for maintenance.

Data related to incident-caused congestion is sketchy; however, some examples exist. The Los Angeles 42-mile freeway electronic surveillance project produced reductions in delay of 65 percent, and others have reported approximately a 50 percent reduction, particularly when service patrols are included. At another location in Los Angeles where incidents are monitored through a combination of detector data and closed circuit television cameras, incident management teams are dispatched to clear major incidents. The average duration of lane blockages during incidents has been reduced from 42 minutes to 21 minutes. Based on over ten years' experience in the Los Angeles area, the California Department of Transportation (Caltrans) has seen a 5:l or 6:l benefit/cost ratio. A recent study for Caltrans on strategies to reduce large-truck contributions to freeway congestion also showed significant benefits associated with incident management programs (see Table 3.7).

The Illinois DOT Emergency Traffic Patrol in 1985 provided 107,924 expressway motorist assists in the Chicago area. This effort consists of 35 roving vehicles and 50 people covering approximately 100 miles of freeways. Certain non-priceable benefits which add to the effectiveness of the patrol are:

- motorist sense of security
- improved public relations
- reduced requests that require no police function
- improved safety in minimizing secondary accident'potential

Low cost techniques that are growing in use in incident management schemes are Citizen Band radio and cellular telephones. Both use direct communication from the motorist on the road. The cellular technology is just being tapped. For example, it may be possible to advertise a phone number that motorists can use to call in traffic information.

IMPLEMENTATION: The documented impacts of freeway management improvements reflect the combined effect during peak periods of freeway entry control and incident management. Results have been impressive. During congested periods, decreases in travel time on the freeways of 10 to 45 percent are probable. For all sections of a freeway currently operating as congested (15-20 mph), approximately 60 percent of these sections could be upgraded to relatively free-flow through the use of freeway surveillance and management.

As freeways become more congested, incident detection and management systems will become even more important. The process from conceptual planning to completed system in an urban area can take 5 to 10 years. This fact makes it imperative for many of our urban areas to start initiating these activities as soon as possible. Marketing efforts, in particular, are needed early in the process to assure that the public and elected officials will understand the impacts of these traffic management efforts. Some metropolitan areas have established "Congestion Management Teams," with specific responsibilities for planning, implementing, monitoring and identifying these activities.

A solid planning effort is needed initially to obtain the input and cooperation of all the public agencies at the federal, state and local levels. In most cases, the state highway agency or state department of transportation (DOT) will have the responsibility and funds to implement these actions.

References

1. Federal Highway Administration. *Urban and Suburban Highway Congestion.* Working Paper No. 10. Washington, D.C. ,: FHWA, December 1987.
2. Federal Highway Administration. *Urban Traffic Congestion-A Perspective to the Ear* 2020. San Francisco, California: Region 9 Office of FHWA, September 1987.
3. R. Sumner et al. Freeway *Management Handbook* Vols. l-4. Washington, D.C. : Federal Highway Administration, May 1983.
4. G. Urbanek and R. *Rogers. Alternative Surveillance Concepts and Methods for Freeway Incident Management.* Report DOT-FH011-8813. Washington, D.C. : Federal Highway Administration, March 1978.
5. Federal Highway Administration. *Quantification of Urban Freeway Congestion and Analysis of Remedial Measures.* Report FHWA/RD-87/052. Washington, D.C.: FHWA, October 1987.

ACTION: Integrated Freeway and Arterial Network Surveillance and Control [Ref. l]

DESCRIPTION: Additional improvements are possible by combining arterial control and surveillance with adjoining *freeway* control and surveillance activities. Motorists seeking to avoid the congested freeway may wish to use parallel arterial routes or other freeways, which in turn increases congestion on these facilities. Traffic waiting to enter the congested freeway may spill onto adjacent surface streets, further aggravating congestion. An integrated freeway and arterial network surveillance system consists of the major elements already discussed in the previous section, but applied to the arterial system as well.

BENEFITS/COSTS: The only operational integrated freeway and arterial project is in New York State. The Information for Motorists (INFORM) project was conceived to optimize traffic flow through a 35 mile long and 5 mile wide corridor of freeways and arterials in Long Island by integrating ramp metering, coordinated traffic signal control, and variable message signing into one comprehensive system sharing the same software and database. INFORM provides realtime traffic information to motorists, centralize arterial traffic signal control and monitor traffic flow. Ramp metering and diversionary route signing coupled with coordinated arterial traffic signal control will soon be added to the project.

Both California and Texas are embarking on similar ventures. An integrated corridor concept is being initiated by the Los Angeles County Transportation Commission (LACK) for the Santa Monica freeway corridor, twelve miles long and five miles wide with five arterial alternative routes. In this case effective traffic management systems are already in operation in the city of Los Angeles in cooperation with Caltrans. A common data base will be developed for control and motorist information as traffic enters the corridor. Personal computer and telephone information access and in-vehicle navigation information are part of the state-of-the-art activities proposed. Another ambitious project is underway in Texas. Called PEGASUS, it will incorporate elements of HOV lane control, freeway control and surveillance, and corridor traffic signal control in an integrated system. The system is being designed for use on a statewide basis in order to make the most efficient use of maintenance and computer-programming personnel and to allow standardization and interchangeability of hardware. The first installation is proposed for Houston.

IMPLEMENTATION: This activity of sophisticated integrated solutions is in its infancy. The technology is available. The barrier to further efforts (large or small, simple or sophisticated) is largely institutional. Quite simply, the major constraint is human and interagency communications. Only by working side by side, as a part of the whole solution, can ultimate improvements result. One example is a case involving coordination of a large number of agencies in the New York City area. Institutional problems were resolved and a consortium of 15 transportation and traffic enforcement agencies were joined together as TRANSCOM, an incident management and communications clearinghouse. TRANSCOM receives updated information on roadway emergency situations, special events, and any other incidents that require immediate attention. Staff evaluates the information and transmits it to all member agencies via encoded pagers, giving them real-time information on events affecting traffic conditions, to ensure quick effective responses. One of the state-of-the-art activities is transmission of digitized pictures of incident scenes by cellular telephone back to a personal computer at the TRANSCOM center. To minimize disruptions and improve the efficiency of the highway system TRANSCOM is developing a regional database of all scheduled construction and maintenance projections and preparing prearranged diversionary plans for the major highways in the region.

Another example is the Traffic Management Teams in Texas, which are accomplishing similar results. There are currently I2 operating in the state, where they cover the seven largest metropolitan areas and the nine largest cities as well as other smaller areas. Each team brings together professionals from the various traffic-related agencies in the area, and they work cooperatively to solve the area's traffic problems. The rapid spread of the team concept and their wide acceptance among the larger cities in Texas are evidence that simple communications will most often lead to cooperation. The Texas State Department of Highways and Public Tmnsportation has also sponsored an aggressive education program for both highway/traffic professionals and the general public. The viability of coordinated traffic management schemes is demonstrated through workshops, seminars, and training courses.

A more systematic approach to urban traffic management and catalytic efforts around the country similar to the two examples above, can ultimately result in many more savings in motorist delay. Applied marketing techniques early in the planning and project development process can also establish backing of the public and elected officials for these traffic management strategies.

Reference

1. Federal Highway Administration. *Urban Traffic Congestion--A Perspective to the Year* 2020. San Francisco, California: Region 9 Office of FHWA, September 1987.

ACTION: Motorist Information Systems [Ref. 1]

DESCRIPTION: Motorist information systems represent one important element of a freeway management system. Such systems consist of one or more of the following: changeable message signs, highway advisory radio, and/or in-vehicle navigation and information systems (covered under "Future Technologies' ') .

BENEFITS/COSTS: In 14 years of experience in the Los Angeles area, the California Department of Transportation points out several beneficial features of changeable message signs:

- Early warning reduced the speeds of vehicles approaching a queue, resulting in fewer secondary accidents and associated delay. Decelerations were less severe into congested spots.
- Signing increased diversion at off-ramps that were greater than 1/2 mile upstream from incidents.
- Signing for lane blockages induced lane changing away from that lane.
- Signs upstream from freeway-to-freeway interchanges were highly efficient.

Improvements in the above traffic characteristics contribute toward a savings in delay time.

Highway advisory radio involves the broadcast of pertinent driving- and travel-related information to motorists. This technique is used at the approaches to airport parking facilities, near construction sites on freeways, and in mobile units by incident management teams. The transmitters have a range of approximately 2 miles in each direction. The messages are changed remotely to reflect actual conditions.

An extensive use of highway advisory radio is proposed for the San Francisco Bay area as a part of an areawide traffic management system. Transmitters are recommended for placement approximately every four miles in the 216 mile network to allow continuous coverage. It is relatively inexpensive when compared to other system elements and offers a unique opportunity for providing better and more timely information to motorists.

IMPLEMENTATION: A substantial amount of time is needed to plan and implement a motorist information system. Its implementation requires the design and construction of the system, using the steps required for a typical highway construction project. However, the nature of this system is such that experts in the areas of electronics and information systems must be involved in addition to highway and traffic engineers.

The implementation of a motorist information system must include local officials as well as the state highway department or state DOT. Communication media in the area must also be included in the planning stage.

Ideally, the system should be designed as an integral part of an areawide freeway management program, as described previously.

Reference

1. Federal Highway Administration. *Urban Traffic Congestion--A Perspective to the year 2020.* San Francisco, California: Region 9 Office of FHWA, September 1987.

ACTION: Ramp Metering [Ref. l]

DESCRIPTION: Ramp metering has proven to be one of the most cost-effective techniques for improving traffic flow on freeways. Using a modified traffic signal placed at the end of a ramp, ramp metering allows traffic to enter the highway traffic either at pretimed intervals or at times determined by traffic volume on the ramp or on the highway. Although additional delays are incurred by the ramp traffic, mainline capacities are protected and the overall operational efficiency, usually measured in terms of travel time or speed, is improved. High occupancy vehicle bypass lanes on the metered ramps have been used to provide incentives for Carpools, Vanpools and buses.

BENEFITS/COSTS: A survey made for the Federal Highway Administration of seven ramp metering systems in the United States and Canada revealed that average highway speeds increased by 29 percent after installing ramp metering. When delays on ramps are included, average speeds still increased 20 percent and travel times decreased 16.5 percent. An analysis of the FLOW system in Seattle (ramp metering and HOV lanes) revealed that in addition to similar improvements in speed and travel time, highway volumes increased from 12 to 40 percent as a result of ramp metering. An additional benefit from ramp metering is a decrease in the accident rate. Reductions from 20 to 58 percent have been achieved through improved merging operations.

Various levels of entrance ramp control have been implemented across the country. Some are used to simply improve the conditions at specific problem merge areas. Two ramp metered locations in Detroit resulted in increases of 1.6% in volume and 114% in speed (27 to 59.9 mph) at one location and increases of 11.6% in volume with 64% in speed (35.2 to 58.0 mph) at another. A few states have improved conditions along longer sections of routes in urban areas and are now attempting system-wide applications, notably in California and Texas. Average speed increases of 30 percent commonly result, while reducing freeway congestion by approximately 60 percent. In addition, Minnesota recently compared conditions on one freeway prior to system activation to conditions during 14 years of system operation. They showed a 16 percent increase in average peak hour freeway speeds (37 to 43 mph) and a 25 percent increase in average peak period volumes.

Traffic-responsive metering often produces results that are generally 5 to 10 percent greater than those of pretimed metering. A traffic-responsive ramp control experiment in Los Angeles obtained a 100 percent increase in average speed (25 to 52 mph), a 20 percent decrease in ramp wait times, and a 3 percent increase in freeway volumes. Although this is probably a “best” case example, it points to the greater flexibility of traffk-responsive control and the impacts possible. Experiences in several cities have shown 10 to 20 percent more traffic throughput during peak periods after metering was instituted.

A special type of metering system was installed in 1974 at the Oakland-Bay Bridge approaching San Francisco. The system consists of stop-and-go traffic signals located over each of the 15 lanes about 1000 feet downstream from the toll booths. The metering system allows all multi-occupant vehicles to proceed nonstop under a green light, while other vehicles are metered. The result is a more flexible system accommodating the variations in buses and Carpools while at the same time allowing the bridge to carry vehicles at its peak efficiency. Prior to constructing the metering project only 7 per cent of the morning commute periods were incident-free. After metering, 20 percent were incident-free. Travel time savings averaged from 2.5 to 3.5 minutes per vehicle. Tow services, incident detection equipment, motorist call boxes, changeable message signs, and closed circuit television are additional elements implemented in the Bay Bridge computerized traffic management system.

IMPLEMENTATION: A substantial amount of time is needed to plan and implement a ramp metering system. Its implementation requires the design and construction of the system, using the steps required for a typical highway construction project. However, the nature of this system is such that experts in the area of electronics and information systems must be involved.

The implementation of a system must include local officials as well as the state highway department or state DOT. Communication media in the area must also be included in the planning stage. Ideally, the system should be designed as an integral part of an areawide freeway management program, as described previously.

Although ramp metering can provide some important improvements to the flow of freeway traffic, it is not always an appropriate solution for a number of reasons; as summarized below.

Individual ramps selected for this technique must be in locations where arterials feeding the ramps will not become severely congested as a consequence of such action. Improvements to freeway flows could be made at the expense of transferring a more severe congestion problem to those local streets.

Ramp metering may be most effective in the suburbs, but not so effective within the more densely populated portions of urban areas. Thus, the implementation of ramp meters could in some cases be viewed as a significant disadvantage for motorists who enter the system at ramps that are closer to the urban core.

Motorists may choose to by-pass those ramps where metering has been installed to avoid delays. If a large number of people do so, this diversion could result in the creation of congestion on arterials that might not otherwise have a problem.

There may be other local problems that could occur. Good advance planning is needed to identify them and develop strategies to resolve them.

Reference

1. F. Spielberg et al. *Evaluation of Freeway High-Occupancy Vehicle Lanes and Ramp Metering.* Report DOT-OST078-050. Washington, D.C.: Federal Highway Administration, March 1980.

ACTION: Providing Additional Lanes Without Widening the Freeway

DESCRIPTION: In some cases, low cost geometric modifications can be made to increase highway capacity on a temporary basis. These modifications include: 1) using one or more shoulders as travel lanes (this is often done only during peak hours and in the peak direction), and 2) reducing lane widths to provide additional lanes within the existing pavement.

BENEFITS/COSTS: Significant increases in capacity (up to as much as 30 percent and more) are possible. Such increases have been achieved with either no increase in accident rates or even some reductions. Although such treatments should be considered temporary, an FHWA staff study [Ref. 1] found that for 1984, in the 37 cities with populations over 1 million, almost 32 percent of the urban freeway mileage could experience reduced congestion through such low-cost measures. Costs will normally vary depending on the individual circumstances and the condition of the existing freeway, but in general costs per mile will be $1.3 million for construction and engineering, and $12,000 per year for maintenance. Overall, low-cost improvements have the potential of returning a benefit/cost ratio of up to 71.

IMPLEMENTATION: These actions require careful preplanning and design, in order to avoid any potential safety problems. The state highway agency would plan and design these improvements as a typical highway project, and enter into a construction contract or lane striping contract in the usual manner.

Cooperation and coordination between the state highway agency and the traffic enforcement officials responsible for enforcement (e.g., the state police) is essential. Since the use of breakdown lanes is not consistent with federal design criteria, if the highway facility is on the federal-aid system then federal approval will also be required.

When this action is being considered, it typically generates opposition from traffic enforcement agencies and the public. Their concerns are safety related, because the emergency lane is used for traffic flow rather than for use by emergency vehicles or breakdowns. Also, there is concern that the flow from entrance ramps will be adversely affected. These are all legitimate concerns which should be addressed. The response to these concerns should consider:

- Advanced information and education required to describe the program.
- Additional warning signs that alert drivers to the conditions.
- The construction of intermittent break-down lanes that can be used temporarily to store disabled vehicles.
- Strict enforcement of the modified traffic conditions.

Reference

1. Federal Highway Administration. *Urban and Suburban Highway Congestion.* Working Paper No. 10. Washington, D.C. : FHWA, December 1987.

ACTION: High Occupancy Vehicle (HOV) Facilities [Refs. 1-5]

DESCRIPTION: There are several types of HOV facilities that can be implemented, including:

Exclusive HOV Facility, Separate Right-Of-Way. A roadway or lane(s) developed in a separate right-of-way and designated for the exclusive use of high-occupancy vehicles.

Exclusive HOV Facility, Freeway Right-Of-Way. Roadways or lanes built within the freeway right-of-way that are physically separated from other freeway lanes and are designated for the exclusive use of high-occupancy vehicles during at least portions of the day.

Concurrent Flow Lane. A freeway lane in the peak-direction of travel (commonly the inside lane), not physically separated from the other general traffic lanes, and designated for the exclusive use by high-occupancy vehicles (usually buses, Vanpools and Carpools) during at least portions of the day.

Contraflow Lane. A freeway lane (commonly the inside lane) located in the *off-peak direction* of travel designated for exclusive use by high-occupancy vehicles (usually buses only or buses and Vanpools) traveling in the peak direction during at least portions of the day. The lane is typically separated from the off-peak direction travel lanes by insertable plastic posts or pylons.

BENEFITS/COSTS: The primary purpose of HOV facilities is to increase the people-moving (versus vehicle-moving) capacity of a highway. As shown in Table 3.1, the results can be quite dramatic. High-occupancy vehicle facilities have been planned, designed and constructed in a 3- to 8-year time frame. The construction involves well-known highway technology. High-occupancy vehicle lanes can be opened as each section is completed. It frequently represents the fastest approach for getting some form of fixed transit guideway into operation.

Evaluation of HOV priority lanes on congested highways has shown that the benefit/cost ratios for such projects are frequently in excess of 6 to 1. Table 3.2 summarizes typical capital costs for several HOV's.

HOV facilities have reduced travel times for users by an average of six percent over the travel times experienced prior to implementation. They also have reduced the number of vehicle miles traveled by approximately five percent. For lane addition projects, the travel time reduction for the general purpose lanes is about half that for the HOV lanes. Lane-taking facilities, however, experience an average increase in travel time of 12 percent for the general purpose lane vehicles. The costs of an HOV facility will vary greatly depending upon the type of facility. Reserved lanes may cost a few thousand dollars per lane for signings and markings, while separate facilities may cost up to $5 million per lane-mile, similar to the costs for lane widening projects.

Table 3.1--Impact of HOV Facilities on Person Movement and Vehicle Occupancy [Refs. 6, 7]

	HOV FACILITY				GENERAL PURPOSE LANES		
FACILITY	Buses	Cats/Vans	People	Occupancy	Vehicles	People	Occupancy
Shirley Highway (No. Virginia)							
0630-0930	506	4128	35460	7.65	21792	27143	1.25
0700-0800	191	2273	18500	7.51	8000	10000	1.25
I-495 Contraflow Lane (N.Y.)							
0700-0930	1600	—	72000	45.00	11525	15000	1.30
0730-0830	650	—	30000	46.15	4650	6000	1.29
Oakland Bay Bridge (CA)							
0600-0900	367	4183	32000	7.03	20178	25000	1.24
I-5: FLOW System (Seattle)							
0645-0745	425	(AllVeh.)	2700	6.35	2000	2300	1.15
1645-1745	380	(AllVeh.)	2200	5.79	(per lane)		

Source: Reference (8), Page 46

Table 3.2-Estimated Capital Costs for High-Occupancy Vehicle Projects

Transitway Facility	Capital Cost 1($1000's) Design	Construction	Total/Mile	Funding Sources
EXCLUSIVE IN SEPARATE ROW				
1. Ottawa, Canada (Canadian $)				
Southeast Transitway	$ 7,870	$39,570	$31,600	75% Province, 25% Municipality
West Tmnsitway	6,680	41,000	16,400	75% Province, 25% Municipality
Southwest Transitway	7,850	25,700	17,700	75% Province, 25% Municipality
2. Pittsburgh, PA				
East PatWay	12,300	81,500	16,588	UMTA, Penn DOT, Allegheny Co.
South PatWay	N.A.	27,000	7,714	UMTA, Penn DOT, Allegheny Co.
FACILITIES IN FREEWAY ROW				
Exclusive Facilities				
1. Houston, Texas				
I-10 (Katy), ll.5 mi.	–	–	2,700	UMTA, Houston Metro, State & Federal Highway
I-45 (North), 19.7 mi.	–	–	4,800	UMTA, Houston Metro, State & Federal Highway
2. Los Angeles, I-10 (El Monte)	–	–	4,692	UMTA, Federal Aid Urban, State Highway
3. Washington, D.C.				
I-395 (Shirley)	–	–	4,000	Federal Aid Interstate
I-66	–	–	31,000	Federal Aid Interstate
Concurrent Flow				
1. Honolulu, Moanalua Fwy.	5	10	7	Federal & State Highway
2. Los Angeles, Rte. 91	25	250	34	Federal & State Highway
3. Miami, I-95	N.A.	20,800	2,773	Federal & State Highway
4. Orange County, Rte. 55	10	400	37	Federal & State Highway
5. Orlando, I-4	–	–	350	Federal Aid Interstate
6. San Francisco, CA				
Bay Bridge	–	–	–	Toll Revenues
us 101	–	–	–	–
7. Seattle, WA				
I-5	–	–	1,442	Federal & State Highway
SR 520	100	100	67	State Highway
Contraflow				
1. Honolulu, Kalanianole Hwy.	17.5	120	62	Federal & State Highway
2. New York City, NJ Rt. 495	187	342	212[2]	Federal & Port Authority of NY & NJ
3. San Francisco, CA, US 101	0	205	49	Caltrans

Source: Institute of Transportation Engineers 1985, Survey of Operating Transitway Projects.
N.A. =not applicable.
-Data not available or provided.
'Implementation year dollars.
2Construction cost includes new access road.

It is important to remember that minimum Carpool requirements must be selected carefully to optimize the efficiency of the facility. The selection must still allow for growth as more commuters choose to switch to carpooling arrangements and to take advantage of the time and fuel savings. A minimum of 3 persons per vehicle has traditionally been the most beneficial application, although two-person carpools have also been accepted. Allowing too small of a minimum occupancy can create excess demand for the facility, thereby negating any time savings and incentives, as well as reducing the potential for continued growth of the facility. Some trial and error may be needed before the right number is established.

IMPLEMENTATION: There are several important actions that must be taken to plan and implement HOV's which involve many organizations and individuals. The major elements required include:

1. **Planning**
   - physical identification and planning the location
   - support facilities, such as fringe parking lots and added bus terminals
   - additional buses required
   - market survey
   - demand analysis to estimate the number of people and vehicles likely to use the HOV facility
2. **Physical Design and Construction of the Facility**
   - typical highway design and construction project
3. **Operation**
   - facilities (e.g., buses)
   - enforcement
   - maintenance
4. **Marketing and Promotion**
   - a major effort is required in order to provide incentives for people to form Carpools and Vanpools and to utilize express buses.

There are a number of HOV preferential treatments that may be effective in promoting HOV use when implemented as elements of a regional HOV strategy. The use of the following features are very important in planning for a successful HOV facility:

- park and ride lots
- metered ramp by-pass
- signal priority
- exclusive ramps
- transit malls and auto restricted zones
- preferential tolls
- toll facility preferential lanes
- preferential parking facilities
- preferential parking costs
- turning movement restrictions
- transit passes

References

1. Institute of Transportation Engineers. *The Effectiveness of High Occupancy Vehicles Lanes*. Washington, D.C. : ITE, 1988.
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3. T. Batz. *High Occupancy Vehicle Treatments, Impacts, and Sythesis.* Report No. FHWA/NJ-86-017-7767. Washington, D.C. : Federal Highway Administration, 1987.
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7. Federal Highway Administration. *Transportation Management for Corridors and Activity Centers: Opportunities and Experiences.* Washington, D.C.: FHWA, May 1987.
8. Federal Highway Administration. *Urban and Suburban Highway Congestion.* Working Paper No. 10. Washington, D.C.: FHWA, December 1987.

ACTION: Future Technologies [Ref. l]

Transportation congestion, both in terms of actual numbers as well as that perceived by travelers, has reached intolerable levels in many parts of the nation today. It is likely that congestion will worsen unless new and innovative solutions ate planned, designed and implemented within the near future. In other words, we simply cannot continue to seek traditional solutions to transportation congestion. We must begin now to think about those problems from a different perspective, and develop solutions that take advantage of rapidly developing technological innovations that have application in the real world.

Since the middle of the 1980s the California Department of Transportation (Caltrans) has been pursuing a variety of studies intended to explore various technologies as a method for dealing with problems of congestion and safety. The states of Michigan, Texas, and Massachusetts are also undertaking related various research activities.

Each of those efforts is being undertaken with a major university.* The various efforts underway in the United States are being informally coordinated by an informal group called Mobility 2000. It evolved from a series of meetings that began in 1987 and that are moderated by the Federal Highway Administration. The group is composed of representatives from federal and state transportation agencies, universities, vehicle manufacturers, parts manufacturers, suppliers, and others.

In major studies of highway operational needs for Project 2020, the American Association of State Highway and Transportation Officials (AASHTO), the Highway Users Federation for Safety and Mobility (HUFSAM), the Transportation Alternatives Group (TAG), the Transportation Research Board (TRB), the Federal Highway Administration (FHWA), and others have recognized the need for an increasing role for advanced technology. Mobility 2000 responded by identifying research, development, demonstration programs, and implementation stategies to ensure the earliest national availability of useful technology to address major problems of congestion, pollution, and safety.

The scope of Mobility 2000 extends to all technologies that will improve the efficiency of the transportation system. It is concerned with Advanced Transportation Technology (ATT). Intelligent Vehicle/Highway Systems (IVHS) are one essential element of ATT in that they concentrate on transportation operations, but do not include some of the broader aspects of transportation technology, including alternate fuels, robotics for maintenance and construction, and alternate modal systems. IVHS focuses on two of the nation's most critical problems-congestion and safety. The systems involve partnerships of industry, universities, and all levels of government; vehicles and highways; highway users and providers; manufacturers and customers. The full benefits can only be obtained when the most advanced systems are implemented. However, significant benefits can accrue even from some of the first applications that are currently being tested and demonstrated.

Advanced technology involving communications, computers, displays, and control processes are the available ingredients for developing IVHS. For purposes of discussion and program development, IVHS has been grouped into four generic elements by Mobility 2000:

- Advanced Transportation Management Systems (ATMS)
- Advanced Driver Information Systems (ADIS)
- Automated Vehicle Control (AVC)
- Commercial Operations

ATMS involve the management of a transportation network including freeways and surface streets. ATMS must be adaptive and responsive in realtime to changes in traffic flow. It must include accurate and reliable surveillance and detection systems, manage both freeway and alternate routes on arterials, provide for interconnection of the systems in adjacent communities, and include effective incident management control strategies. ATMS

* The University of California at Berkley 's Institute for Transportation Studies; the University of Michigan Transportation Research Institute; the Texas Transportation Institute at Texas A&M University; and the Center for Transportation Studies at the Massachusetts Institute of Technology.

research can lead to some significant highway system improvements within the near future. California and other states arc testing a number of such actions now.

ADIS is located in an individual's vehicle and interconnected through a communication link with traffic management centers. These systems will provide the motorist with a broad spectrum of trip- and traffic-related information. ADIS includes a navigation system that provides vehicle location and a route planning assistance system that receives information from the traffic center on congestion, incidents, and other traffic information. An on-board database will contain detailed maps and specific locations of services, hospitals, and tourist-related information, such as are found in the "Yellow Pages." Advanced versions will be able to transmit requests for emergency services and information on vehicle location, destination, and speed to the traffic management center. Some limited applications of ADIS are being tested now.

AVC could eventually lead to a fully autonomous vehicle. Such a vehicle would be capable of operating in any traffic environment and traveling portal to portal without driver intervention. Lateral guidance would probably utilize machine vision and pattern recognition. A number of other highly sophisticated sensors and communication devices would provide navigation, collision avoidance, and route optimization capability. Some experiments have begun using collision avoidance systems and adaptive speed controls. On a much less sophisticated scale, cruise control takes over the throttle function from the driver under open road conditions. On a much more sophisticated scale, research on autonomously guided vehicles is underway. Implementation of AVC is a longer term possibility.

Commercial users comprise a special class of highway users. Their concerns and needs differ from the general public. They require ATT elements that go beyond the needs of the individual motorist. The commercial users operate heavy trucks and other commercial vehicles, including taxis. This group also includes public safety vehicles (police, fire, ambulance) and the whole range of vehicles that are not operated by the individual motorist.

Commercial vehicle operations by the year 2000 could be taking full advantage of automatic vehicle identification technologies, as well as weigh-in-motion, automatic vehicle classification, automatic vehicle location, and vehicle management systems.

At a workshop conducted by the Mobility 2000 group in San Antonio on Feb. I5-17,1989, there was a clear consensus that the new technologies briefly described here will result in significant benefits to the motoring public and to society as a whole. These benefits will be measured in terms of reduced congestion, improved safety, reduced pollution, and better use of existing limited land resources. A major cooperative program of research and demonstration currently being formulated at the national level includes all levels of government, the private sector, and universities.

Reference

1. *Proceedings of a Workshop on Intelligent Vehicle/Highway Systems.* Mobility 2000, San Antonio, Texas, February 15, 16-17, 1989.

Arterials and Local Streets

In 1987, approximately 30% of all annual vehicle miles of travel were on arterials and local streets. Improving travel flow on these roads can effectively serve to reduce congestion, air pollution and energy use.

There are approximately 240,000 traffic signals in the country, of which about 54% (130,000) are interconnected in traffic signal systems. These signalized intersections, together with other improvements on the arterial street system, provide significant opportunities for increasing capacity and making better use of existing arterials without major new construction.

The following sections of this Chapter briefly describe the available procedures that should be considered.

ACTION: Super Street Arterials [Ref. l]

DESCRIPTION: Super street arterials are wide, multi-laned arterials with limited access provided from intersecting streets. To the degree possible, major intersecting streets are grade separated, in order to minimize the need for traffic signals. Super streets take full advantage of as many traffic operations improvements as possible, including:

- traffic channelization
- street widening
- intersection widening
- left/right turn lanes
- two-way turn lanes
- turn prohibitions
- one-way streets
- grade separations
- reversible traffic lanes
- railroad grade separations
- improved traffic control devices
- removal of parking
- lighting improvements
- bus turnout bays

These measures generally provide spot or localized reductions in congestion.

BENEFITS/COSTS: Implementation of super arterial streets is similar in concept to the reconstruction and expansion of freeways to increase capacity and to improve traffic flow. But super arterial streets provide even greater increases in capacity. This approach is beneficial for those suburban highway systems that are based upon arterial networks that will not accommodate freeway facilities. Converting a typical suburban arterial with signalized intersections to a super street could increase capacity by as much as 50 to 70 percent, while at the same time significantly reducing delays when at-grade intersections are replaced with grade separations. Although cost data are unavailable at present, the cost per mile could be approximated by using data for typical freeway widening or reconstruction projects, or by using the amount of $5 million per mile.

Although minimal data have been collected to evaluate all of the benefits of traffic operations improvements, one component of super street arterials, these projects have provided as much as a 15 percent increase in vehicular capacity on arterial streets and up to a 20 percent reduction in accidents.

IMPLEMENTATION: The design, construction and operation of a super street arterial will be undertaken by the agency having the administrative jurisdiction for the arterial in question. This would be one or a combination of a state, county or city organization.

The design and construction of such a facility will be expensive and time-consuming, as it is treated in the same way that any large highway construction project will be. Thus it is not a quick solution. There are several important constraints that must be addressed in considering this type of improvement, including land acquisition, opposition from abutting land owners, access to existing and future land parcels, and environmental problems (such as wetlands that might be affected).

Reference

1. Federal Highway Administration. *Urban and Suburban Highway Congestion*. Working Paper No. 10. Washington, DC.,: FHWA, December 1987.

ACTION: Traffic Signal Improvements

DESCRIPTION: It has been estimated that of the approximate 240,000 urban signalized intersections in the United States, about 148,000 need upgrading of physical equipment and signal timing optimization, while another 30,000 are in need of signal timing optimization only [Ref. 1]. Traffic signal improvements generally provide the greatest payoffs for reducing congestion on surface streets. There are a number of relatively basic improvements that can and should be made to improve traffic flow on arterials. They include:

Equipment update-In this case, an inventory of existing traffic control devices should be made to determine if new, more modern equipment can replace them. This would allow for the planning of a more comprehensive set of strategies to improve traffic flow.

Timing Plan Improvements-This action would require a data collection effort in order to update the traffic signal timing to correspond to current traffic flows. Appropriate re-timing of signals has been very successful in improving traffic flows.

Interconnected Signals-Specific improvements could include one or more of the following: interconnected pre-timed signals, traffic actuated signals, interconnected actively managed timing plans, and master controls.

Traffic Signal Removal-Many traffic signals are no longer justified in urban areas due to changes in traffic patterns. Many of these intersections can be better controlled by two-way stop control. For those situations, where peak traffic flows necessitate continued signalized control, but off-peak traffic does not, conversion of control from full to flashing operation can provide significant reductions in delay and congestion during the off-peak times. Removing traffic signals can produce reductions in vehicle delay and in unwarranted stops.

Traffic Signal Maintenance-Traffic signals are often installed with little attention given to the cost and procedures required for maintenance. This is a problem that has become particularly critical in recent years, as more sophisticated traffic control devices are installed.

There are several categories of maintenance which should be considered:

- Preventive maintenance, to be performed at regular intervals in order to avoid unnecessary problems;
- Response maintenance, which includes quick response to emergency situations as well as trouble shooting; and
- Design modification, which deals with the need to monitor new equipment as well as signals placed in new locations in order to insure safe and effective operation.

BENEFITS/COSTS: Tables 3.3, 3.4 and 3.5 illustrate the costs and benefits of signal improvements on various signal systems using project experience from around the United States.

Table 3.3~Travel Time Savings Resulting From Traffic Signal Improvements

Before Condition	After Condition	Percent Improvement in Speed or Travel Time
Non-interconnected Pre-Timed Signals with Old Timing Plans	Advanced Computer Based Control	25%
Interconnected Pre-Timed Signals With Old Timing Plans	Advance Computer Based Control	17.5%
Non-Interconnected Signals with Traffic-Actuated Controllers	Advanced Computer Based Control	16%
Interconnected Pre-Timed Signals with Actively Managed Timing	Advanced Computer Based Control Plans	8%
Interconnected Pre-Timed Signals Various Forms of Master Control and Various Qualities of Timing Plans	Optimization of Signal Timing Plans. No Changes in Hardware	12%

Source: Ref. 1

Table 3.4-Annual Impacts of Quality of Traffic Flow Strategies Per One Million of Urban Population

Action	Reduction in vehicle hours of travel (millions)
Traffic Signal System Improvements (Interconnect, Optimize Timing, Advanced Master Control)	19.5 (9.8%)
Traffic Signal Removal and Flashing	3.2 (1.6%)
Right-Turn-On-Red-After-Stop	2.6 (1.3%)

Source: Ref. 2

Table 3.5~Summary of Annual Costs of Various Traffic Signal Improvements

Traffic control Improvement	Implementation Cost per Signal ($)	Equivalent Capital Outlay ($)	Operations and Maintenance ($)	Total $
Optimize Previously Interconnected Signals	–	–	300-400	300-400
Interconnect and Optimii	2,000-10,000	260-1,300	500-1,400	760-2,700
Advanced Computer-Based Master Control (Includii Interconnection and Optimization)	5,000-13,000	760-1,800	1,100-2,000	1,860-3,800
Approximate Marginal Cost of Advanced Computer Based Master Control	3,000	500	600	1,100

Source: Ref. 1

IMPLEMENTATION: The first action required to improve the traffic signal system in an urban area is to inventory the existing intersections where signals are in-place, the conditions being controlled, and the traffic being served. Traffic and its relationship to the existing traffic signal system must be analyzed to determine if the system is current and still appropriate. Then, a comprehensive policy must be developed to implement the actions described above.

Traffic signal locations and timing should be developed in accordance with the ITE, state and local warrants established for that purpose [Ref. 2]. (For more information about these warrants, contact your local traffic engineering department.)

Although the methods available to upgrade traffic signals are relatively straightforward, this action is often overlooked by public officials as an effective way to improve traffic flow. In fact, there are cases where public officials may react to public pressure for installing new traffic signals faster than they will to improving existing signals. Installing new signals could, in fact, further exacerbate the problems of congestion in a particular area.

References

1. *Federal Highway Administration. Urban and Suburban Highway Congestion,* Working Paper No. 10. Washington, D.C.,: FHWA, December 1987.
2. EA. Wagner. *Energy Impacts of Urban Transportation Improvements* Washington, D.C. ,: Institute of Transportation Engineers, August 1980.
3. Institute of Tmnsportation Engineers. *Transportation and Traffic Engineering Handbook,* Second Edition. Washington, D.C. ,: ITE, 1982.

ACTION: Computerized Signal Systems [Ref. 1]

DESCRIPTION: Computerized traffic signal systems usually involve three elements. These include (1) coordinating groups of signals by using either interconnection or highly accurate timebased coordinators, (2) systematically optimizing the signal timing parameters of pretimed signals or the interval settings of traffic actuated signals, and (3) advanced traffic control functions by using master computer controls which include increased timing plan flexibility, dynamic traffic responsive control features, and on-line traffic performance monitoring and control system components operation.

BENEFITS/COSTS: Project experience from around the United States indicates that:

1. Interconnecting previously uncoordinated signals, pretimed signals, and providing newly optimized timing plans and a central master control system has resulted in a 25% reduction in travel time.
2. Installing advanced computer control has resulted in a 17.5 % reduction in travel time when compared to interconnected pretimed signals operating with old timing plans.
3. Installing advanced computer control has resulted in a 16% reduction in travel time when compared to non-interconnected, traffic actuated controls.
4. Installing advanced computer control, when compared to interconnected multi-dial pretimed control with relatively active signal timing management, has resulted in an 8% reduction in travel time.
5. Optimizing traffic signal timing plans, when compared to previously interconnected signals with various master control forms and varying previous signal timing qualities, has resulted in a 12% reduction in travel time.

Table 3.5 (shown earlier) summarizes the annual costs per signalized intersection for the three basic traffic signal system improvements.

To promote signal improvements on a national basis, FHWA initiated the National Signal Timing Optimization Project in 1980 [Ref. 2]. The project demonstrated that signal retiming projects can be extremely cost-effective, with benefit to cost (B/C) ratios conservatively estimated at 10:1 when considering fuel savings only. When the benefits of reduced delay and stops are added, the B/C ratio doubles to 20:1. An aggressive program of signal timing optimization underway in California indicated a benefit-cost ratio of 58 to 1. Applied to 3172 signals in the state, the program has resulted in over a 15 percent reduction in vehicular delays and a 16 percent reduction in stops over three years. Overall travel times through these systems have dropped by 7.2 percent. The reduction in fuel expenditures (8.6%) alone will produce savings almost 18 times the total cost of implementing the signal retime program.

IMPLEMENTATION: Several factors have impeded more widespread and shillful application of efficient traffic signal system management techniques:

- Some smaller jurisdictions within major metropolitan areas have either no traffic engineering capability or severely underdeveloped and under-budgeted capability. In such cases, traffic signal system management often is limited to the most rudimentary installation and maintenance functions, with little or no effort or skill focused on optimizing system operation.
- Even in large central city jurisdictions with mature traffic engineering departments, total staff and budget is usually insufficient to keep up with routine installation and traffic control device maintenance, responding to complaints, maintaining traffic records, etc., with no time left over for aggressive operational management improvement functions.
- A wide variety of traflic control system improvements are eligible for federal aid funds including expenditures for modern control system components and for developing signal timing plans. Under the 1978 Surface Transportation Assistance Act, many jurisdictions often can develop and implement traffic signal system projects funded entirely through federal assistance. Often, however, budget constraints at the local level still inhibit continuing strong management of the traffic control system once developed.
- Viewed from a metropolitan perspective, major traffic control system improvements, such as computer-based signal systems, would be implemented most cost-effectively by a multijurisdictional team. However, most urban areas either have not tried or have not been able to work out a coordinated areawide approach to the problem.
- State Departments of Transportation strongly influence the allocation of federal aid urban funds. Some states are not oriented to urban area traffic operations as they might be, and stress high-capital road-building as problem solutions at the expense of adequate funding for traflic control system improvements.

While these problems are significant in many urban areas, traffic engineers are uniquely qualified to overcome them. An especially important consideration is that the potential effectiveness of traffic signal system improvements does not depend on urban area size. Such programs can be and are implemented successfully in all sizes and types of urban areas.

References

1. F. A. Wagner. *Energy Impacts of Urban Transportation Improvements*. Washington, D.C. : Institute of Transportation Engineers, August 1980.
2. Federal Highway Administration. *Urban Traffic Congestion-A Perspective to the Year 2020*. San Francisco, California: Region 9 Office of FHWA, September 1987.

ACTION: Arterial Surveillance and Management

DESCRIPTION: Although there are some limitations on what can be achieved because typical arterials include so many at-grade intersections, the following kinds of actions can be taken:

1. Incident detection and follow-up action to remove incidents:
   - Service patrols
   - Roving tow vehicles at key sites
   - Motorist information system, including radio announcements, citizen-band radios and cellular phones
   - Incident teams
2. Intersection surveillance and monitoring, using:
   - Loop detectors
   - Interconnected signal systems
   - Video monitoring of key intersections
3. Parking control and management on key arterials, with greater enforcement of parking regulations on designated through arterials
4. Integration of freeway and arterial management programs (as described earlier in this chapter.
5. Traffic surveillance and metering

The following example from Los Angeles provides some insights to how this technique can help.

Los Angeles Case Study [Ref. l]

The first phase of the Los Angeles ATSAC (Automated Traffic Surveillance and Control) System was installed in June of 1984, one month before the Olympic Games. Since then, ATSAC has been in continuous operation, new features have been added to the system, and implementation in other areas is underway.

One of the most distinctive features of the Los Angeles ATSAC System is the very extensive use of traffic surveillance data for a variety of traffic management functions. Traffic surveillance data is used in support of the following functions: monitoring of traffic conditions with computer graphics displays, critical intersection control, traffic responsive control, development of ad hoc timing plans for non-recurring situations, transportation planning, and system performance evaluation.

As a general policy, traffic system detectors are placed in each marked approach lane at intersections of arterial streets. At signalized intersections of an arterial street with a local street, semiactuated signal control is used; data from the detectors on the local street are not brought back to the control center and in most cases there are no detectors on the arterial street at these locations.

The ATSAC System has given Los Angeles the capability for responding more effectively to short term and long term changes in traffic demand, developing new signal timing plans, evaluating the performance of current timing strategies, and identifying equipment malfunctions. The ATSAC System has thus provided the Los Angeles Department of Transportation with an extremely powerful tool for traffic management.

BENEFITS/COSTS: A major cost of planning and implementing an effective arterial surveillance and management system is associated with intersection control devices (these were described earlier in this chapter). Another cost item will include police and traffic control personnel.

The benefits to be derived from such a program are significant. Earlier sections summarized many of those benefits. The following Boston case study will further illustrate their value [Ref. 2].

In August 1986, Boston initiated Phase I of a Traffic Relief Program (TRB). The program was an interagency effort of the Boston Transportation Department and the Boston Police Department, to provide increased enforcement of the city's traffic and parking regulations on congested roadways in downtown Boston. The TRP is a reaffirmation of the city's philosophy that major arterials' primary function is the movement of traffic during periods of heavy traffic flow. This philosophy can be expressed in the following six objectives:

1. Reduce vehicular travel time along travel corridors
2. Increase street/intersection capacity
3. Eliminate vehicular blockage at intersections
4. Eliminate double parking
5. Eliminate pedestrian/vehicular conflicts at intersections and thus reduce the potential number of accidents.
6. Provide clear regulatory and street name signage.

The 30-day trial period for Phase I of the TRP began on September 8, 1986, and was concentrated on three major downtown streets.

The main objective of Phase I was to reduce vehicular travel time along the three corridors. To accomplish this, the City of Boston imposed the following revisions and actions in the corridors:

- No-stopping zones were established along most portions of the three arterials from 7 a.m. to 7 p.m.
- Over 180 parking meters were removed.
- Cab stands, tour bus stops, and handicapped parking spaces were relocated to alternate locations.
- No-stopping zones were established on some intersecting side streets to improve flow into the three main corridors.
- Particular problem areas, such as queuing at large garages, received remedial treatment.
- Enforcement activities featured a close working relationship between the police department (12 motorcycle officers) and the enforcement division of the Transportation Department (20 meter maids). They were instructed to keep traffic moving and not to hand out tickets, unless necessary. The effectiveness of the program was evaluated by collecting travel time data

and traffic counts, recording parking violations, and analyzing the collected data.

The following results were achieved:

- Before the TRP, average speeds in downtown Boston were highest in the early morning hours and decreased gradually until they bottomed out around 3 p.m.
- Average speeds after TRP appear to be relatively constant throughout the day from 9 a.m. to 6 p.m. They are somewhat higher before 9 a.m.
- The most significant increase in speeds occurs at 3 p.m. showing approximately a 28% increase. At 7 a.m., the TRP resulted in only a 6% increase in speeds.
- As can be expected, because average speeds increased as a result of the TRP, travel times decreased. They were in the range of 28-30% for three of the routes surveyed, and an 18% decrease was noted on northbound Congress Street. This resulted in a time savings to motorists of over 1200 hours.
- A summary of parking violations showed that double-parking incidents decreased on all streets during all time periods. After the initial heavy enforcement effort, the program became self enforcing as a result of a high degree of voluntary compliance.
- An air quality analysis for carbon monoxide showed an overall improvement of 15% to 18% as measured by eight-hour concentration standards and a 13%-33% improvement in one-hour concentrations. In comparison, previous efforts in the State Implementation Plan (SIP) had limited success in improving air quality in Boston.

The TRP has demonstrated that city traffic flow can be controlled and improved. This program is one of the most significant traffic programs implemented by the City of Boston. The program was well received both by the public and the press, and significant improvements were realized on a number of fronts. Travel times were decreased by nearly 30% and average speeds rose from 6-9 mph to 942 mph. The number of parking violations was reduced by nearly 60%, and significant improvements were achieved reducing CO concentrations along the arterials.

IMPLEMENTATION: The planning and implementation of an arterial surveillance and management system is a major undertaking. The development of such a system must be coordinated with a number of area wide programs, such as those described earlier. They must also be developed in cooperation with all local jurisdictions that may be involved, property abutters who will be affected, business interests, local elected officials, and citizen groups.

This is not a short term action. It is one which may require several years of planning, and it may be faced with opposition by all of the groups mentioned above.

Specific implementation actions will include a combination of the actions described earlier, and those which would follow.

References

1. Institute of Transportation Engineers. *Strategies to Alleviate Traffic Congestion*. Proceedings of ITE's 1987 National Conference, San Diego, California, March 8-l1, 1987. Washington, D.C.: ITE, 1987.
2. R. Dimino, G. Bezkorovainy, and B. Campbell. "A Successful Traffic Relief Program." ***ITE*** Journal 57 (August 1987).

ACTION: Intersection Improvements [Ref. 1, 2]

DESCRIPTION: Intersection traffic control devices can be used to improve the flow of vehicles and the safe passage of pedestrians. These devices include stop signs, yield signs, traffic signs, turning lanes, traffic islands, channelization, and improved design.

BENEFITS/COSTS: The costs associated with planning and implementing this technique are modest, and vary depending upon the complexity and the number installed. The benefits are substantial, because of the separation of traffic and the enhancement of the safety of operation. There are no readily available data to define the costs and benefits, because there is such a wide range of circumstances that are appropriate for this action.

IMPLEMENTATION: In designing and improving arterial intersections that are at grade, eleven principles have been established by the Institute of Transportation Engineers (ITE) which should be incorporated wherever possible. They are:

1. Reduce the number of conflict points among vehicular movements.
2. Control the relative speed of vehicles both entering and leaving an intersection.
3. Coordinate the type of traffic control devices used (such as stop signs or traffic signals) with the volume of traffic using an intersection.
4. Select the proper type of intersection to serve the volume of traffic being served. Low volumes can be served with no controls, whereas high levels of traffic may require more expensive and sophisticated treatments such as turning lanes or even at grade separation structures.
5. When traffic volumes are high, separate right turn and/or left turn lanes may be required.
6. Avoid multiple and compound merging and diverging maneuvers. Multiple merging or diverging requires complex driver decisions and creates additional conflicts.
7. Separate conflict points. Intersection hazards and delays are increased when intersection maneuver areas are too close together or when they overlap. These conflicts may be separated to provide drivers with sufficient time (and distance) between successive maneuvers for them to cope with the traffic situation.

8. Favor the heaviest and fastest flows. The heaviest and fastest flows should be given preference in intersection design to minimize hazard and delay.
9. Reduce area of conflict. Excessive intersection area causes driver confusion and inefficient operations. When intersections have excessive areas of conflict, channelization should be employed.
10. Segregate nonhomogeneous flows. Separate lanes should be provided at intersections where there are appreciable volumes of traffic traveling at different speeds. For example, separate turning lanes should be provided for turning vehicles.
II. Consider the needs of pedestrians and bicyclists. For example, when there are pedestrians crossing wide streets, refuge islands should be provided so that more than five lanes do not have to be crossed at a time.

References

1. Institute of Transportation Engineers. ***Transportation and Traffic Engineering Handbook,*** Second Edition. Washington, D.C.: ITE, 1982
2. T. Neuman. ***Intersection Channelization: Design Guide.*** NCHRP Report 279. Washington, D.C. : Transportation Research Board, November 1985.

ACTION: Turn Prohibitions [Ref. l]

DESCRIPTION: Conflicts between turning vehicles and pedestrians and between turning vehicles and other vehicles approaching from the opposite direction can cause congestion delay and safety problems at intersections and driveway access points. Prohibiting turns is a means of eliminating such conflicts and reducing congestion and accidents.

It is not always necessary to prohibit turning movements at all times in order to alleviate a congestion or accident problem resulting from conflicts produced by turning vehicles. Turning movements should be prohibited only during those hours when study data indicate that a congestion or accident problem exists and when a suitable alternative route is available. When part-time restrictions are used, the signs used to notify motorists of the restrictions must be designed and placed so that the time of the restriction is clearly visible to approaching motorists.

At intersections controlled by traffic signals, turns can be restricted to certain phases of the signal operation by use of separate signal displays and appropriate signs. This type of turn restriction is generally most effective when a separate lane is provided for turning vehicles. The signal phasing techniques can be used to eliminate the conflict between turning vehicles and pedestrians or between turning vehicles and opposing traffic.

BENEFITS/COSTS: Because turn restrictions cause a change in travel path, reliable data relative to the total impact of turn restrictions on accidents are difficult to obtain. Data compiled in San Francisco indicated that accidents at four intersections with turn restrictions were reduced by 38% to 52%. All of the intersections were high-volume intersections used by 30,000 to 50,000 motorists on an average day [Ref. 1].

The prohibition of turning movements at driveways between intersections is frequently accomplished by construction of a median divider. A study in Wichita, Kansas, reported that prohibition of turns between intersections by use of a median reduced accidents between intersections by amounts ranging from 43% to 69% during the first three years after the median was installed. During the same period, accidents at intersections where turns were not prohibited increased by amounts ranging from 12% to 38%. However, because accidents between intersections originally represented more than 60% of the total accidents on the street section affected by the construction, the median construction resulted in a net accident reduction ranging from 12% to 38%.

An alternative to turn restrictions is the designation of a separate lane for storage of vehicles waiting to make left turns. This traffic control technique can take the form of "continuous two-way left-turn lanes" which can be used by motorists proceeding in either direction. Left-turn storage lanes can also be established with pavement markings for one direction of traffic only on approaches to intersections where left-turning vehicles create accident or congestion problems. Designation of such may, however, require that parking be prohibited, and this could create a need for a study of curb parking supply, demand, and so on. The advantages of the turn lane must be compared to the impact of parking restrictions in the determination of the best course of action.

IMPLEMENTATION: A modest planning effort is required to identify arterial locations for installations. A routine design and construction process is then implemented, using appropriate design standards. Turn prohibition studies should consider:

1. The amount of congestion and delay caused by turning movements.
2. The number of collisions involving vehicles making the turning movement.
3. The availability of suitable alternative travel paths if turns are restricted.
4. The possible impact of traffic diversion on congestion and accidents at intersections that would be required to accommodate the traffic diverted by the turning restriction.
5. Possible adverse environmental impacts caused by re-routed traffic.
6. The feasibility of alternative solutions, such as provision of separate storage lanes for the turning movements and, at signalized intersections, the use of special turn-movement phasing.

Reference

1. Institute of Transportation Engineers. ***Transportation and Traffic Engineering Handbook,*** Second Edition. Washington, D.C. : ITE, 1982.

ACTION: One Way Streets [Ref. 1]

DESCRIPTION: Although most streets and highways are designed for use by two-way traffic, high volumes of traffic and vehicle conflicts often lead to consideration of one-way traffic regulations. In major activity centers, such as the central business districts of cities with large traffic volumes and closely spaced intersections, one-way traffic regulations are frequently used because of traffic signal timing considerations and to improve street capacity. In the development of new activity centers such as shopping centers, sports arenas, industrial parks, and so on, one-way regulations are frequently incorporated into original street and traffic plans.

One-way streets are generally operated in one of three ways:

1. A street on which traffic moves in one direction at all times.
2. A street that is normally one-way but at certain times may be operated in the reverse direction to provide additional capacity in the predominant direction of flow.
3. A street that normally carries two-way traffic but which during peak traffic hours may be operated as a one-way street, usually in the heavier direction of flow. Such a street may be operated in one direction during the morning peak hour and in the opposite direction during the evening peak hour, with two-way traffic during all other hours.

BENEFITS/COSTS: One-way streets provide increased capacity, as they:

- Reduce intersection delays caused by vehicle turning-movement conflicts and pedestrian-vehicle conflicts.
- Allow lane-width adjustments that increase the capacity of existing lanes or actually provide an additional lane.
- Reduce travel time.
- Permit improvements in public transit operations, such as routings without turnback loops (out on one street and return on the parallel streets).
- Permit turns from more than one lane and doing so at more intersections than would be possible with two-way operation.
- Redistribute traffic to relieve congestion on adjacent streets.
- Simplify traffic signal timing by:
  - Permitting improved progressive movement of traffic.
  - Reducing multiphase signal requirements by making minor streets one-way away from complex areas or intersections.

They also result in increased safety, as they may:

- Reduce vehicle-pedestrian and vehicle-vehicle conflicts at intersections.
- Prevent pedestrian entrapment between opposing traffic streams.
- Improve driver's field of vision at intersection approaches.

They also result in more cost-effective operation, as they:

- Provide additional capacity to satisfy traffic requirements for a substantial period of time without large capital expenditures.

And they can meet other community objectives, as they:

- Permit stage developments of a master plan.
- Meet changing traffic patterns almost immediately and at negligible cost.
- Facilitate the loading and unloading of commercial vehicles with minimal impact on traffic flows.
- Save sidewalks, trees and other valuable frontage assets that could otherwise be lost because of the widening of existing two-way streets.

IMPLEMENTATION: The amount of data to be collected and analyzed in planning for one-way traffic regulations will depend largely on the size and complexity of the one-way system under consideration. As a general rule, two-way streets should be made one-way only when:

1. It can be shown that a specific traffic problem will be alleviated or the overall effkiency of the transportation system will be improved.
2. One-way operation is more desirable and cost-effective than alternative solutions.
3. Parallel streets of suitable capacity, preferably not more than a block apart, are available or can be constructed.
4. Such streets provide adequate traffic service to the area traversed and carry traffic through and beyond the congested area.
5. Safe transition to two-way operation can be provided at the end points of the one-way sections.
6. Proper transit service can be maintained.
7. Such streets are consistent with the master street or highway plan, and compatible with abutting land uses.

Reference

1. Institute of Transportation Engineers. ***Transportation and Traffic Engineering Handbook,*** Second Edition. Washington, D.C.: ITE, 1982.

ACTION: Reversible Traffic lanes [Ref. 1]

DESCRIPTION: Arterial routes that are normally operated as two-way streets, particularly those in urban areas, can experience much greater peak-hour traffic volumes in one direction than in the other. With the reversible lane system, one or more lanes are designated for movement one-way during part of the day and in the opposite direction during another part of the day. On a three-lane road, for example, the center lane might normally operate as a two-way left-turn lane, but during the peak hour operate in the direction of greater flow. One of the outstanding examples of multiple reversible lanes is the eight-lane Outer Drive in Chicago, which operates a 6-2 lane split during peak traffic periods. The purpose of the reversible lane system is to provide an extra lane or lanes for use by the dominant direction of flow. Two increasingly used methods are to reverse the flow of an entire street during peak-hour periods or to make a two-way street operate one-way during that period.

BENEFITS/COSTS: A reversible-lane system is one of the most efficient methods of increasing rush-period capacity of existing streets. ***With minimal capital costs,*** it takes advantage of unused capacity in the direction of lighter traffic flow by making one or more of those lanes available to the heavier traffic flow. The result is that all lanes are better used. The system is particularly effective on bridges and in tunnels, where the cost to provide additional capacity would be high and, perhaps, impossible. Some disadvantages are:

1. Capacity is reduced for minor flows during peak periods.
2. Reversible lanes frequently create operational problems at their termini.
3. Concentrated control efforts may be needed to prevent violations of the lane-use regulations.

IMPLEMENTATION: There are several factors to be considered in determining whether reversible lanes are justified:

Evidence of congestion. If the level of service during certain periods decreases to a point that it is evident that traffic demand is is in excess of actual capacity, the possibility of using reversible lanes should be considered.

Time of congestion. It should be determined that the periods during which congestion occurs are periodic and predictable. Traffic lanes can usually only be reversed at a fixed time each day.

Ratio of directional traffic volumes. Lane reversal requires that the additional capacity for the heavier direction be taken from the traffic moving in the opposite direction. Traffic counts by lane will determine whether or not the number of lanes in one direction can be reduced, how many lanes should be allocated to each direction, and when the reversal should begin and end. On major streets, there should be at least two lanes for traffic flowing in the minor direction.

Capacity at access points. There must be adequate capacity at end points of the reversible-lane system, with an easy transition of vehicles between the normal and reversed-lane conditions. Installation of a reversible-lane system with insufficient end-point capacity may simply aggravate or relocate the congestion problem.

Once a reversible system is deemed necessary and feasible, the method of designating lanes to be reversed and the direction of flow must be selected. Three general methods are used: (1) special traffic signals suspended over each lane, (2) permanent signs advising motorist of the changes in traffic regulations and the hours they are in effect, and (3) physical barriers, such as traffic cones, signs on portable pedestals, and movable divisional medians.

Although reversible-lane operation is principally used on existing streets and roadways, it can also be designed into new streets, freeways and expressways, bridges, and tunnels. Applications to older limited-access facilities is difficult because most such roadways have fixed medians separating the two directions of traffic. By constructing special median crossing locations and by properly using traffic control devices, however, even these facilities can be used in a reversible manner. Obviously, extreme care must be exercised to maintain safe operation.

Reference

1. Institute of Transportation Engineers. ***Transportation and Traffic Engineering Handbook,*** Second Edition. Washington, D.C. : ITE, 1982.

ACTION: Improved Traffic Control Devices [Refs. 1, 2]

DESCRIPTION: Traffic control devices include traffic signs and markings. They are the primary means of regulating, warning or guiding traffic on all streets and highways. They may include variable message signs.

Traffic signs fall into three broad functional classifications:

1. ***Regulatory signs***: used to impose legal restrictions applicable to particular locations and unenforceable without such signs.
2. ***Warning signs:*** used to call attention to hazardous conditions, actual or potential, that would otherwise not be readily apparent.
3. ***Guide or informational signs:*** used to provide directions to motorists, including route designations, destinations, available services, points of interest, and other geographic, recreational or cultural sites.

Variable message signs are used to inform drivers of regulations or instructions that are applicable only during certain periods of the day or under certain traffic conditions. The need for and use of variable message signs has increased considerably over the past several years. These variable message signs, which can be changed manually, by remote control, or by automatic controls that can “sense” the conditions that require special messages, have applications in each of the functional classifications.

Improvements in any type of road signing, the intent of which is to provide better information to the driver, will be beneficial in addressing congestion issues. Improved directional signs, route markers, large street signs, signs on mast arms, etc., are all means of reducing the level of uncertainty (and thus potential indecision) of drivers.

Traffic markings include all traffic lines (both longitudinal and transverse), symbols, words, object markers, delineators, cones or other devices, except signs, that are applied upon or attached to the pavement or mounted at the side of the road to guide traffic or warn of an obstruction. Traffic markings have certain definite functions to perform in the proper control of vehicular and pedestrian traffic. They serve to regulate, to guide, to channel traffic into the proper position on the street or highway, and to supplement the regulations or warnings of other traffic control devices. They also serve as a psychological barrier for opposing streams of traffic, as a warning device for restricted sight and passing distances, and provide information for turning movement, special zones, and so on. As an aid to pedestrians, they channelize movement into locations of safest crossing and, in effect, provide for an extension of the sidewalk across the roadway. Traffic markings aid the vehicle driver in many respects without diverting attention from the roadway.

Transverse marking lines are used for: crosswalks, stop lines, railroad crossings, parking space markings, word and symbol markings and curb markings.

Miscellaneous traffic control devices are used to guide traffic in and around work areas, to alert traffic to hazards that are ahead, and to provide a means of identifying specific locations on streets and highways. They include: barricades, vertical panels, drums, barricade warning lights, rumble strips and milepost markers.

BENEFITS/COSTS: The costs associated with planning and implementing this technique are modest, and vary depending upon complexity and the number installed. The benefits are substantial, because of the separation of traffic and the enhancement of the safety of operation.

IMPLEMENTATION: A modest planning effort is required to identify locations for installations. Then a routine design and construction process is implemented, using appropriate design standards. There are five basic factors that must be employed in designing and maintaining traffic control devices :

1. Design: the combination of physical features such as size, colors, and shape needed to command attention and convey a message.
2. **Placement:** the installation of devices so that they are within the lines of vision of the users, and thus able to command attention and allow time for response.

3. **Operation:** the application of devices so that they meet traffic requirements in a uniform and consistent manner, fulfill a need, command respect, and allow time for response.
4. **Maintenance:** the upkeep of devices to retain legibility and visibility, or the removal of devices if not needed.
5. **Uniformity:** the uniform application of similar devices for similar situations.

References

1. Institute of Transportation Engineers. ***Transportation and Traffic Engineering Handbook,*** Second Edition. Washington, D.C. : ITE, 1982.
2. U.S. Department of Transportation. ***Manual on Uniform Traffic Control Devices.*** Washington, DC.: Federal Highway Administration, 1988.

ACTION: Parking Management [Ref. l-4]

DESCRIPTION: A parking management program is basically any plan by which parking space is provided, controlled, regulated, or restricted in any manner. Parking management actions can be categorized into six major categories: on-street parking, off-street parking, fringe and corridor parking, pricing, enforcement and adjudication, and marketing. The major types of action in each category are shown in Table 3-6.

It is important to understand that parking management programs can be undertaken for many reasons. In many cases, communities want to have a sound parking program that provides a sufficient amount of parking space to serve residential, commercial, and retail activities. In other situations, communities use parking policies to achieve different objectives, such as to improve environmental quality, encourage a shift to different modes of transportation, or to preserve sufficient access for local residents.

Table 3-6-Types of parking Management Tactics

On-Street Parking Supply	Off-Street Parking Supply in Activity Centers	Fringe and Corridor Parking	Pricing	Enforcement and Adjudication	Marketing
. Add or remove spaces • Change Mix of Short and Long-Term Parking • Parking Restrictions – Peak Period Restrictions – Off-Peak Restrictions – Alternate Side Parking By Time of Day and/or Day of Week – Permissible Parking Durations – Prohibitions on Parkmg Before Specified Hours • Residential Parking Permit Programs • Carpool/Vanpool Preferential Parking – Carpool/Vanpool Meters – Carpool/Vanpool Stickers - Loading Zone Regulations – Bus - Taxi – Delivery – Diplomat	• Expand or Restrict Off-Street Supply in CBD and Activity Centers – Zoning Requirements • Minimum Requirements • Maximize Requirements . Joint Use – Constrain Normal Growth in Supply • Maximize Ceiling (i.e. Freeze) on CBD Spaces • Reduced Minimum Parking Requirements Through HOV and Transit Incentives • Restrict Principal use Parking Facilities – Construct New Lots and Garages • Change Mix of Short and Long-Term Parking • Restrict Parking Before or During Selected Hours of the Day • Preferential Parking – Carpool/Vanpool Parking – Handicapped Parking – Small Vehicle Spaces	• Fringe Parking · Park and Ride Parking · Carpool/Vanpool Parking	• Change Parking Rates – Increase Bates • Parking Price Increase - Parking Bate Structure Revision - Parking Tax • Parking Surcharge – Decrease Bates – Free Parkmg in CBD – Differential Pricing Programs • Short-Term vs. Long-Term Bates • Carpool/Vanpool Discounts • Vehicle Size Discounts • Geographically Differentiated Bates • Monthly Contract Bates • Merchant Shopper Discounts – stamp Programs – Token Programs • Employer Parking Subsidies – Reduce Subsidies – Transit/HOV Subsidies	• Enforcement – Non-Police Enforcement Personnel – Ticketing – Towing – Booting • Adjudication – Administrative – Judicial	• Advertising – Brochures – Maps -Media • Convenience Programs (i.e. Monthly Contracts)

Source: John Direnzo, et al, Study of Parking Management Tactics, U.S. DOT Report DOT-FH-11-9537, December 1979

Research has shown that when parking at employment sites is free or provided at a very low cost (i.e., subsidized by a person's employer) people generally drive to work alone rather than use Carpools or transit. According to 1980 Census data, about three of four cars driven to work are parked in employer provided spaces [Ref. 5]. Consequently, if there is a desire to promote ridesharing and transit use, then a study of parking policies should be undertaken to insure compatibility between strategies.

BENEFITS/COSTS: The benefits and costs of parking management actions depend upon the specific strategy or strategies to be implemented, as well as the objectives to be achieved. Following are some examples.

In May of 1983, Los Angeles based Commuter Computer discontinued its parking subsidy of solo drivers. At that time, the fee was $58 per month to park in the building. With discontinuance of the subsidy, solo driving fell from an average of 42% during the last four months of free parking to 9% during the first three months of full-price parking.

Children's Hospital of San Francisco instituted a parking fee program which costs $34 per month for solo drivers and $30 per month for a two-person Carpool; three-person carpools and Vanpools park free. This pricing structure was instrumental in the formation of 55 car-pools and Vanpools between 1978 and 1980.

When the Canadian government discontinued free parking for its employees in Ottawa, 20% fewer commuters drove alone to work, and there was a 16% increase in bus use.

IMPLEMENTATION: Each of the several parking management strategies summarized in Table 3-6 requires a different, yet related set of actions which depend upon the program objectives. The first step required is to clearly establish those objectives; for example:

- Increase the highway capacity of selected arterials.
- Discourage the use of single occupancy autos during the peak.
- Provide more parking for neighborhoods.

These objectives must be clearly defined. Then a planning process must be established which identifies the target areas for implementation, the people and businesses affected, and the conditions under which certain actions would be appropriate. For example, if a residential parking permit program is to be implemented, planners must be sure that [Ref. 6]:

- The neighborhood has a high enough density to ensure success;

[Ref. 6]. An increase in rates will encourage travelers to share rides, use transit to reduce an individual's costs, or find a cheaper place to park. If the increase is limited to all-day rates, the action may free spaces for shoppers and visitors. If rates in commercial lots and garages are not directly regulated, a municipal tax or surcharge may provide an indirect means of increasing rates at those facilities. This action would be taken to deal with the following:

- Traffic congestion consistently develops on or near the center during peak travel hours.
- Air pollutant concentrations develop in or near the center during peak travel hours.
- All-day parkers leave insufficient spaces for shoppers and other short-term visitors to center.
- Street capacity in or near the center is insufficient to handle traffic volumes expected if business expansion plans are implemented.

To consider the potential impacts and benefits of increasing parking rates, the following conditions must be evaluated:

Revenue maintenance-Parking revenues are used to cover the costs of debt service and facility operations and maintenance. Patronage loss may be high if the increase is large or if less expensive parking exists or can be developed near the center, and the resulting revenue loss may reduce income below minimal requirements despite increased fees collected from remaining users.

Transit availability-The action will be more effective in reducing vehicle trips if good transit service is available to most employees working in the center.

High parking occupancy rate-In the absence of business expansion plans, no more than 15% of off-street, all-day spaces should be vacant in a major employment center at the end of the morning commuting peak if the action is to appear justified.

There are several potential problems that must be addressed in considering this action:

- Businesses may oppose the increase as limiting their ability to attract employees or customers.
- Garage and lot owners and users probably will oppose the increase.
- Residents of nearby neighborhoods may object to the increase if center users shift to parking on their streets.
- Motorists will oppose the increase.

References

1. Federal Highway Administration. ***Urban and Suburban Highway Congestion,*** Working Paper No. 10. Washington, D.C.,: FHWA, December 1987.

2. Institute of Transportation Engineers. ***Transportation and Traffic Engineering Handbook***, Second Edition. Washington, D.C.: ITE, 1982.
3. J. DiRenzo et ***al. Study of Parking Management Tactics.*** Report DOT-FH-B-9537. Washington, D.C. : Federal Highway Administration, December 1979.
4. M. McShane and M. Meyer. "Relating Parking Policies to Urban Goals." ***Transportation 11,*** 1982.
5. D.C. Shoup and D.H . Pickrell. ***Free Parking As A Transportation Problem.*** Report No. DOT-05-800. Washington, D.C.: Federal Highway Administration, October 1980.
6. J.H. Batchelder, M. Golenberg, J.A. Howard, and H.S. Levinson. ***Simplified Procedures For Evaluating Low Cost TSM Projects.*** NCHRP Report No. 263. Washington, D.C. : Transportation Research Board, October 1983.

ACTION: Goods Movement Management [Ref. l]

DESCRIPTION: The management of urban arterial traffic must look at all of the elements of traffic congestion and establish an integrated set of actions. One action to consider is the possibility of better managing the time and location of truck deliveries and pick-ups to minimize unnecessary congestion.

The movement of goods into and out of urban areas is an essential part of our lives. Consequently, any change in the methods of moving goods must be done with care. Unfortunately, them is little experience or research results to help guide actions in this area.

An FHWA Handbook [Ref. l] prepared to provide guidance on dealing with issues of urban goods movement recommended the following actions:

Traffic management. Short-range transportation system management (TSM) measures to improve the flow of freight and passenger vehicles.

Improvements at shipping/receiving points. On street loading and unloading can be facilitated by designing additional curb space for loading zones and enforcing time restrictions.

Reducing operational and physical constraints. Changing the timing of traffic signals or using demand-actuated signals at intersections with large volumes of trucks to compensate for the acceleration, deceleration and turning characteristics of trucks. Intersections can be widened and horizontal and vertical obstacles (e.g., islands, lamps and utility poles) can be removed or relocated.

Changes in business operating practices. Business operating practices to reduce the time requited for pick-up and delivery, reduce the transport costs of shippers and receivers, and improve the performance of the transportation system.

Changes* in *public policy. The most commonly considered technique for relief of truck-induced congestion is the separation of trucks from other traffic.

Land-use planning, zoning and industrial location policies and building regulations requiring off-street loading and unloading facilities may be used to separate freight-oriented from other activities.

BENEFITS/COSTS: The Los Angeles Olympic experience [Refs. 2, 3] showed that the removal of a significant portion of trucks through ***goods movement management*** during peak period traffic can effectively reduce overall congestion. The development of the off-peak hour system for urban goods movement through various incentives (tax and otherwise) assists in the reduction of peak period traffic congestion. The development of metropolitan area truck management plans could also be used to spread the commercial demand for truck traffic in the urban core and suburban areas to off-peak hours.

During the peak hours in Los Angeles during the 1984 Olympics, truck traffic was down about 6 percent overall, more than 15 percent below normal on some freeways. Additionally, the combination of free-flow and fewer trucks produced a 42 percent reduction in truck-related freeway accidents, 58 percent regionwide.

A recent study conducted for the California Department of Transportation examined possible strategies for reducing the contribution of large trucks to peak-hour freeway congestion [Ref. 4]. Four major strategies were examined:

- ***Traffic Management***-Modify high-accident freeway locations, provide motorist information on freeway conditions, and enforce safe truck operations.
- ***Incident Management***-Aggressive monitoring of and response to truck-involved accidents.
- ***Night Shipping and Receiving***-Require business establishments to do most of their shipping and receiving at night.
- ***Peak-period Truck Ban***-Exclude large trucks from core area freeways from 7-9 am and 4-6 pm.

Table 3.7 presents the estimated impacts of these strategies.

Table 3-7--Comparison of Freeway/Truck Management Strategies (Millions of Dollars Annually)

			Economic Impacts					
			Direct					
Strategy	Feasible	Freeway Congestion Relief	Motor Carriers (2)	Other Vehicles (2)	Shippers/ Receivers (3)	Indirect: CA Business Sales (4)	Air Quality (5)	Implementation cost (6)
Traffic Management (7)	Yes	+ +	$8	$121	+	3 $8	+	$20-40
Incident Management (7)	Yes	+	$4	$44	+		+	$3-5
Night Shipping and Receiving (8)	Maybe	+	$3	+	– $2,200	– $913	+	$2-3
Peak Period Ban – Core Freeways (8,9)	Unlikely	+	– $43	$7	–	– $28	–	$2-3

Source: reference 4.

Notes:

++ Significant positive impact
\+ Modest positive impact
\- Modest negative impact

(1) 1988 Dollars
(2) Time and vehicle operating cost savings (+) or cost increases (-)
(3) Logisucs costs savings (+) or cost increases (-)
(4) Changes in volume of business sales (output) in 1988 relative to baseline forecast
Traffic and incident strategies were combined because their individual direct (motor carrier) impacts were too small to be modeledreliably.
(5) Not quantified
(6) Ten-year annualized implementation costs
(7) Los Angeles, San Francisco, and San Diego
(8) Los Angeles and San Francisco only
(9) Assumes 80 percent of peak period truck miles of travel are diverted to arterials; 20 percent diverted tooffpeak periods (midday or night)

IMPLEMENTATION: Any of the above mentioned strategies will require regulatory or legislative authority to be effective. They also involve coordination among the public, political leaders, truck operators, developers, and private businesses. Because all urban areas are not alike, the institutional hurdles will vary from one location to another. Institutional strategies require both incentives and penalties to gain an acceptable level of compliance.

In order to effectively develop a policy on urban goods movement, it would be helpful to carry out the following actions:

- Establish a forum among business, labor, trucking and the government sectors to facilitate the alteration of truck delivery schedules.
- Make changes to local and state government regulations (e.g., local noise abatement ordinances, parking restrictions, and restrictions on deliveries).
- Identify and make modifications to operations (e.g., work hours for both receivers and shippers).

References

1. Institute of Transportation Engineers. ***Strategies to Alleviate Traffic Congestion.*** Proceedings of ITE's 1987 National Conference, San Diego, California, March 8-11, 1987. Washington, D.C.: ITE, 1987.
2. Federal Highway Administration. Urban ***and Suburban Highway Congestion,*** Working Paper No. 10. Washington, D.C.,: FHWA, December 1987.
3. Federal Highway Administration. ***Urban Traffic Congestion-A Perspective to the Year 2020.*** San Francisco, California: Region 9 Office of FH WA, September 1987.
4. Cambridge Systematics. "Urban Freeway Gridlock Study." Report prepared for the California Department of Transportation, 1988.

ACTION: Arterial Access Management [Refs. l-3]

DESCRIPTION: By employing a program of access management a number of state and local highway agencies are finding it possible to improve both average travel speeds and capacity of arterials. Access management elements often include one or more of the following:

- the physical restriction of left turns,
- restricting curb cuts and direct access driveways,
- separating obvious conflict areas,
- eliminating parking,
- locating intersections at no less than minimum intervals, and
- construction of frontage roads to collect local business traffic and funnel it to nearby intersections.

BENEFITS/COSTS: Without an access management program along arterial highways, capital investment for roadway improvements and/or relocation is required at periodic intervals. This cycle is a result of continually trying to satisfy traffic demands which are often a result of increased business activity, which is influenced by improved traffic conditions, which leads to further traffic demands. The number of conflict points among vehicles rises as a result of an increasing number of driveways, causing the capacity at a specific level of service to diminish. Vehicle delay increases, and safety and comfort are reduced.

The cost of allowing unplanned development to occur along arterials can be great because the inevitable solution calls for more capital expenditure as the traffic conditions reach intolerable proportions. However, if proper planning is utilized, costs can be minimized.

IMPLEMENTATION: Controlling or managing access along arterial highways is perhaps one of the most difficult tasks facing local officials and transportation engineers. This difficulty comes from a time-honored tradition and, in some cases, a legal right for land owners abutting a road to have access to their land. In addition, the process for land development decisions is often very different from that for transportation system planning. There is often very little, if any, coordination between decision-making bodies, yet decisions by any one of them can have a significant impact on the region. One approach for providing this coordination is to undertake a corridor-level planning study. Corridor analyses which assess future demands and capacity of freeway and parallel arterials and evaluate major development proposals provide essential information to decision makers.

Site access studies are also an essential part of access management programs. "Site access study" is a term used by transportation/land use planners and traffic engineers to describe an evaluation of how trips generated by new or changing land uses will be served by an existing or future transportation network. The narrower term "traffic impact study" emphasizes the effect of site generated traffic on the road network.

A site access study involves technical analyses applied to a distinct study area, which may range from one or two key intersections to the entire transportation network within a mile, or several miles, of the site. Site access studies are performed both for private developers and public agencies, and may be funded by the developer, the public agency, or even a third party seeking an independent opinion. Sometimes local governments authorize and pay for the study but require reimbursement from the developer.

Site access studies are often used as a basis for establishing developers' shares of future transportation improvements. This places great importance on certain elements of the technical analyses, such as trip generation rates, trip distribution patterns, mode split analyses, and the percentage of site trips arriving and departing during the peak hour The emphasis on privately financed improvements or contributions has also led to the extension of site access study area boundaries, to ensure that the widest range of public concerns is included.

Site access studies may be simple or complex, depending on the development project under consideration. A simple study would be required for a small retail store or day care center to be built on a one acre tract and occupied within one year. A complex study would be needed for a 100-acre tract on which 3 to 4 million square feet of development consisting of hotels, office buildings, a retail mall and residential units are to be built, with occupancy occurring over 10 to 15 years. The same basic technical analyses will be performed for both studies, but the 100-acre tract involves much more complex issues and therefore calls for more detailed technical analyses and more experienced professional judgments. Both the study cost and the study time frame increase with the complexity of the project.

References

1. Federal Highway Administration. ***Urban and Suburban Highway Congestion,*** Working Paper No. 10. Washington, D.C. ,: FHWA, December 1987.
2. Federal Highway Administration. ***Urban Traffic Congestion-A Perspective to the Year*** 2020. San Francisco, California: Region 9 Office of FHWA, September 1987.
3. Institute of Transportation Engineers. ***Strategies to Alleviate Traffic Congestion.*** Proceedings of ITE's 1987 National Conference, San Diego, California, March 8-11, 1987. Washington, D.C.: ITE, 1987.

ACTION: High Occupancy Vehicle (HOV) Facilities on Arterials [Refs. l-8]

DESCRIPTION: Priority treatments for high occupancy vehicles (HOV's) provides for more effective management of scarce highway space during peak periods by moving more people in fewer vehicles. High occupancy vehicles include buses, Vanpools and carpools. Although a variety of HOV facilities have been used in the U.S., there are usually one of two types currently being used in urban areas on major arterials:

Concurrent Flow-Concurrent flow HOV lanes on surface streets are the most widely applied HOV priority project, found in at least 30 American cities. Most applications have occurred along curb lanes of downtown streets using a minimum of signing and marking.

Most concurrent flow HOV lanes in downtown areas are implemented either by taking an existing lane, removing an on-street parking lane, or by narrowing existing lanes to achieve an extra lane. Restricted right-of-way usually prohibits the construction of a full added lane.

Concurrent flow lanes usually operate during one of the following time periods:

- AM peak hour period
- PM peak hour period
- Both AM and PM peak hour period
- Daylight hours (e.g., 7 AM-6 PM)

Twenty-four-hour restrictions are rare for this type of treatment due to enforcement problems, lack of physical separation, and low HOV demand during off-peak hours.

Contraflow HOV Lanes-Most contraflow applications have occurred on one-way streets, although a few projects have applied the contraflow concept to two-way surface streets, either on the opposite side of a median, or as a reversible center lane. These latter applications are most prevalent on arterial routes outside of the downtown area.

Because a contraflow lane is taken from the off-peak direction flow, there are usually no major physical changes required of the roadway; however, good signing is a critical feature. To date, all contraflow lanes in downtown areas have been limited to buses only due to the typically high bus volumes and safety concerns arising from the contraflow movements.

Most downtown contraflow lanes operate with permanent 24-hour restrictions. The signing, pavement marking, and signalization requirements of this treatment usually dictate the 24-hour restrictions, while minimal enforcement needs enable the lanes to operate efficiently at all times. HOV's usually obtain more significant travel time improvements than on concurrent flow curb lanes because interference with right-turning vehicles is minimized, as is the use of the lane by violators.

Other Downtown HOV Treatments-Apart from the concurrent flow and contraflow lanes described previously, several other supportive HOV treatments can be found in downtown areas, including:

- Exclusive transit streets
- Priority signals for HOV's, particularly buses
- Priority parking spaces for HOV's
- Priority parking rates for HOV's

BENEFITS/COSTS: If properly implemented, HOV facilities can accomplish the following:

1. Induce commuters to shift to higher occupancy travel modes to reduce vehicular demand in peak periods and consequently reduce traffic congestion, energy consumption and air pollution emissions.
2. Increase the person-carrying capacity of critically congested highway corridors to provide increased accessibility to important major activity centers, particularly CBD's.
3. Reduce total person travel time for given levels of vehicular traffic demand served, i.e., optimize for people.
4. Reduce or defer the need to construct additional highway capacity for general purpose traffic thereby gaining the maximum productivity from financial resources.
5. Improve the efficiency and economy of public transit operations and enhance transit service schedule reliability.

Several case studies illustrate the costs and benefits that have been experienced in several metropolitan areas.

New York City

In an effort to improve user travel times and bus reliability in Manhattan, a comprehensive HOV program for buses only was developed by the New York City DOT. Ten right-curb, concurrent flow bus lanes operating under special regulations were designated between June 1982 and November 1982 for a total of 11 miles. Two of the ten bus lanes were entirely new. Success has been achieved through emphasis upon a three part approach of engineering treatments, enforcement strategies, and public education programs.

The preliminary results from a "before and after" evaluation revealed that the average bus saved two to four minutes, representing a 15 to 25 percent increase in speed. Non-bus traffic speeds also increased by 10 to 20 percent due to the separation of buses and autos. Over 3,100 buses and 140,000 riders utilize the lanes on 20 local and 68 express bus routes. These high volumes and time savings translate into large savings in total person-minutes for bus passengers.

Pittsburgh, Pennsylvania

A contraflow right curb bus lane was implemented in June 1981 along a 0.4 mile length of downtown arterial. The lane was installed in order to carry buses diverted from a parallel street, which was being reconstructed.

The bus lane was implemented by removing curb parking from the arterial, which initially had two westbound lanes plus parking. After the bus lane was implemented, there were still two remaining westbound lanes, one of which is used for short term parking and loading during off peak hours. The removal of parking was not a problem in this portion of the downtown. Initially, the bus lane was viewed as an interim treatment until the street under construction was reopened for all traffic. However, the bus lane has operated successfully in such a way that it was made permanent.

The bus lane currently carries approximately 50 to 70 buses in the peak hour. The turns to/from the contraflow lane have not been a problem. The lane is marked with overhead signs, double yellow line delineation, and the diamond symbol. The lane is in effect 24 hours a day.

Key success factors in this case include the following:

- The cooperation of the City of Pittsburgh and the Port Authority of Allegheny County (transit operator).
- The ability to remove-parking.
- Good driver training with regard to speed laws, use of bus flashers and lights, and locations of probable pedestrian interference.
- Self-enforcing design.
- Effective use of curb space along off-peak direction street.
- Potential for travel time improvements for buses.

The network of contraflow bus lanes is viewed as an effective technique for improving bus speeds, reliability, and access to and from downtown Pittsburgh.

Chicago, Illinois

Four contraflow bus lanes were implemented during the early 1980's on streets crossing the State Street transit mall. These right curb lanes operate for seven blocks (0.7 mi.) . The bus lanes were implemented in response to severe conflicts between buses and right turning vehicles which had occurred at virtually every bus stop in the previous mixed mode operation.

The contraflow lanes resulted in a consolidation of bus routes along these four streets. As a result, the lanes are heavily used, each averaging I20 buses per peak period (3 hours), and 50 buses per peak hour. These buses accommodate over 3,800 passengers per peak period and 1,700 per peak hour on each street. Buses save from one to four minutes (1.4-5.7 min/mi) during peak periods with an increase in bus speeds of 15 to 40 percent. A related benefit has been improved reliability of bus service and greater frequency of service across the Loop due to the consolidation of bus routes. The reliability improvements in the Loop also resulted in improved service along the bus routes outside of the downtown area. The combination of decreased travel time and improved reliability allowed the transit operator to eliminate five buses without decreasing service, thereby yielding an annual operating cost savings of about $400,000.

Houston, Texas

A concurrent flow right curb HOV lane operates on both sides of Main Street in downtown Houston. Main Street is a six lane, two-way surface street. The HOV lanes are reserved for buses only on weekdays from 7:00 AM to 6:00 PM. The project was the first HOV treatment implemented in 1971 as a part of a Transit Action Program in Houston. The key feature of the downtown HOV treatment is the prohibition of all turns along the street for the 11 block *(0.7* mi.) section of Main Street. This restriction was imposed at the same time that the bus lanes were implemented. As a result, once a vehicle enters Main Street within a restricted zone (an ll-block segment) it cannot turn off until it reaches the end of the project. There are virtually no access points on Main Street to Parking lots, alleys or hotels. In addition, most off-peak truck loading is performed on cross streets, thus eliminating the obstruction of the bus lanes during the day.

Travel time savings were evidenced for both buses and general traffic. Buses saved from 0.4-2.0 min. General traffic travel times also improved by 0.2-0.6 min. due to the elimination of turns and an overall decrease in volume. The specific travel time impacts of the bus lane versus those of the turn restrictions could not be isolated. At the start of the project, a number of bus routes were rerouted onto Main Street. As a result, the priority lanes carry a high volume of buses throughout the day.

IMPLEMENTATION: Although every HOV treatment is unique in its setting, there are several guidelines which have been common to most of the projects implemented to date. These are the following:

- HOV project planning must ***include various agencies and interest groups*** such as:

  - Traffic
  - Transit
  - Enforcement
  - Ridesharing
  - Taxi operators
  - Business groups, especially small commercial establishments along affected curb space
  - Political leaders
  - Citizen groups
  - Motorist groups (such as the American Automobile Association)

- The project must be ***flexible*** to meet changing conditions in the downtown area, including different pedestrian flows, construction activities, and transit operations.
- ***Enforcement*** is the key to an effective HOV treatment. Adequate enforcement must be in place immediately to establish the credibility of the project.
- ***Public education*** (i.e., marketing) must begin before the project is implemented. The high auto, transit, and pedestrian volumes in the downtown can create volatile and potentially confusing travel movements which must be understood by the public.
- The HOV project must be clearly ***signed*** and ***marked*** to promote understanding of and compliance with the restrictions. These features should be explained as part of the public education.
- Improved travel time ***reliabizity*** and ***efficient movement of persons*** should be the primary goals in a downtown area. Many projects do not show a large actual travel time savings due to the large number of buses, frequent bus stops, and other traffic friction; however, improved reliability has been linked to ridership increases and operating cost savings.
- An HOV project should be planned and implemented in ***the context of other HOV treatments.*** In a tightly defined downtown area, a combination of HOV treatments (e.g., a network of bus lanes, bus lane plus signal priority) can greatly enhance the effectiveness and visibility of the HOV concept. Coordination with transit and ridesharing incentives should also be provided.
- The effects of an HOV project on ***non-users*** as well as users must be analyzed. The implementation of HOV treatments on high volume downtown streets can result in adverse effects on non-HOV traffic if the project is not well-designed. As a general rule, the traffic flow for non-users should not be degraded more than one level-of-service category (e.g., level of service "C" to "D").
- ***Projects*** with ***unsolvable safety and/or operational problems*** should be avoided.
- Most downtown HOV treatments (exclusive of transit malls) can be implemented at at ***low to moderate cost*** relative to other highway or transit changes. Concurrent flow and contraflow lanes can often be initially implemented at a low cost, with additional funds for final signs and markings expended later, once the project has been established. Thus, major initial capital costs can be avoided.

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Enforcement

DESCRIPTION: All of the actions described in this chapter require strict . enforcement in order to achieve success. Enforcement of traffic programs regulations has been a continuing effort of state and local officials, so those needs and procedures are well known. However, whenever individuals are required to change their typical travel behavior, some time is needed to make this happen effectively. The following actions should be taken as an integral part of the programs described in this chapter.

1. Education: adequate time must be given to fully informing the public of changes to be made, and the benefits expected as a result of those changes.
2. Clarity in the description of the new programs.
3. Increased number of enforcement officials in the early stages of implementation.
4. Reasonable fines for failure to comply with the regulations.

BENEFITS/COSTS: There could be substantial expenses involved when a new program is established. The enforcement costs must be factored into the overall strategy for planning and implementation.

The benefits to be derived from these costs, however, have typically been substantial. Each individual action described in this chapter is expected to produce benefits in excess of costs, and in some cases substantial benefits will be achieved.

The most significant benefits will be achieved when a comprehensive, integrated set of actions are implemented. This will also result in more effective enforcement costs as well.

IMPLEMENTATION: Based upon a research project which examined four case study projects in Boston, the following are considered to be essential for all the actions described in this chapter:

1. Enforcement is considered the most important component of all the actions examined in this chapter. Therefore, substantial advanced planning is essential.
2. Heavy enforcement must occur in the early stages of a project so as to reinforce the need for changes in attitudes or behavior. The enforcement can then taper off with periods of increased enforcement occurring later. This type of strategy was apparent in all of the projects examined in the case studies.

   The important lesson to learn from these projects is that every effort should be made to overcome the technical and institutional barriers to effective enforcement so that such action can be instituted during the initial stages of the project.
3. Where possible, the design of the project should provide for self-enforcement. In an auto-restricted zone project, for example, efforts have been made to design the zone so that there is little question that autos do not belong in the area.
4. A very important aspect of an enforcement strategy is the structure of fines which serves as a deterrent in itself if it is sufficiently onerous. Many officials pointed to the parking fine structure and its relatively small fines as a good example of not trying to discourage violations at their source. The use of the "Denver Boot" and the resultant heavy penalties have been shown to have a positive effect on payment of past parking fines and on illegal parking.
5. Enforcement is not effective unless the concept is generally acceptable to the majority of users. Therefore, a public relations or educational effort is necessary to make sure everyone understands the law and to reinforce the message that violators will be prosecuted.

In general, the case studies showed the importance of enforcement in assuring the success of transportation projects. One of the most important conclusions concerned the institutional constraints that limit the participation of enforcement agencies in the transportation planning process.

Enforcement agencies tend to be isolated from the other agencies in a metropolitan area involved with transportation efforts. They have not traditionally held close liaison with planning and implementing agencies, and indeed have often focussed resources on other issues perceived to be more important than traffic law enforcement, e.g., serious crime apprehension and prevention.

On the other hand, transportation planners often ignore the potentially critical role that police officers have in the design of traffic management projects. Police representatives are often incorporated into the project planning process, but usually late in the process and without full recognition of the contribution that such representatives could make. At the local level, transportation agencies should recognize the importance of police participation in project plan development and provide formal opportunities for their participation. These opportunities should be supplemented with financial support where necessary to allow such participation.

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1. M.D. Meyer and J. Sheldon Deen. *Enforcement of Transportation Systems Management Strategies: Four Case Studies.* Report DOT-I-81-24. Washington, D.C.: Federal Highway Administration, September 1980.

Notes

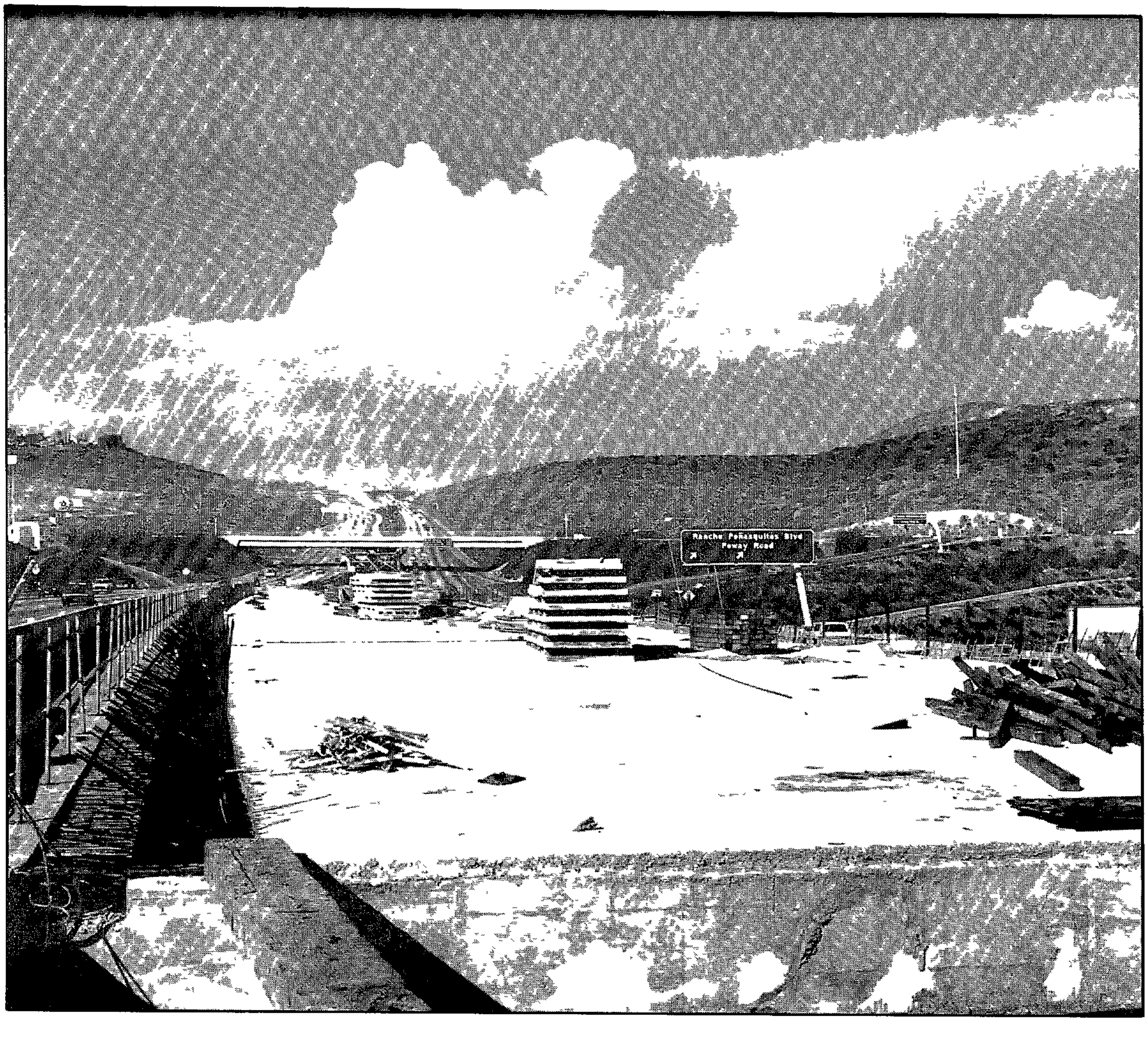

Photo courtesy of Institute of Transportation Services University of California Berkeley

4 Building New Capacity

Our nation's urban areas are integrated and connected by a system of highways and streets (see Table 4.1 for a classification of the roads that constitute this system). This system was originally developed to provide access to new parts of the expanding city. This system was and is directly related to the urban economy and to urban development patterns. Adding new capacity to an urban area's highway system is thus an important action available to community officials. Such action can be undertaken for many reasons. It can provide access to lands on the urban fringe, or open up new industrial and commercial sites for development. It can provide relief to already congested streets by providing a more direct and faster route. New highway capacity can enhance traveler safety by ridding the system of improper or inadequate highway configurations. Importantly, the benefits of new highway construction can occur at the national (if serving a national purpose such as defense), state, regional, and local levels.

ACTION: New Highways

DESCRIPTION: The construction of new highways is being considered in many urban areas as an important means of reducing urban traffic congestion. Such construction, as defined here, means the locating of a new highway in an area where one currently does not exist. Most often these highways are new expressways designed to relieve traffic congestion on nearby roads or to provide access to industrial and/or commercial land.

BENEFITS/COSTS: By attracting vehicles that currently use the existing road system, a new highway can substantially reduce congestion in the highway corridor. The magnitude of this impact depends on how easily the new road can be reached and its ability to serve the employment and shopping sites to which the vehicles are destined. Over many years, the new road itself can attract new development, and unless otherwise guarded against by controlling access, the road could simply become another source of congestion.

Table 4-1--Functional Route Classification

Classification	Function	Typical Percent of Surface Street System Mileage	Continuity	Spacing (miles)	Typical Percent of Surface Street Vehicle-Miles Carried	Direct Land Access	Miium Roadway Intersection Spacing	Speed Limit (mph)	Parking	Comments
Freeway and Expressway	Traffic movement	NA	Continuous	*4*	NA	None	lmile	*45-55*	Prohibited	Supplements capacity of arterial street system and provides high speed mobility
Primary Arterial	Intercommunity and intrametm area Primary-traffic movement Secondary-land access	5-10	Continuous	l-2	40-65	Limited-major generators only	1/2 mile	35-45 in fully developed areas	Prohibited	
Secondary Arterial	Primary-intercommunity, intrametro area, traffic movement Secondary-land access	10-20	Continuous	1/2-1	25-40	Restricted-some movements may be prohibited; number and spacing of driveways controlled	/4 mile	*30-35*	Generally prohibited	Backbone of street system
Collector	Primary-collect/distribute traffic between local streets and arterial system Secondary-land access Tertiary-inter-neighborhood traffic movement	5-10	No necessarily continuous; should not extend across arterials	1/2 or less	5-10	Safety controls; limited regulation	*300* feet	25-30	Limited	Through traffic shold be discouraged
Local	Land access	*60-80*	None	As needed	10-30	Safety controls only	*300* feet	25	Permitted	Through traffic should be discouraged

Source: V. Stover and F. Koepke, *Transportation and Land Development,* Washington, D.C.: Institute of Transportation Engineers, 1988
NA = Not applicable.

Depending on the circumstances, other benefits of new highways could include a decrease in accidents (by diverting traffic from poor roads), improved air quality (by reducing the amount of traffic stopping at intersections), an increase in local tax base (by attracting development and jobs), and the diversion of through traffic or trucks from local streets.

The monetary costs of highway construction vary from one part of the country to another. The project cost can depend on the cost of purchasing the right-of-way, the type of construction materials to be used, the design of the road and whether bridges are involved, and a multitude of other factors. To give a sense of magnitude, Table 4.2 presents data on the cost of constructing one mile of one highway lane.

Officials should be aware that there are other impacts of highway construction that often do not surface until many years later. Because a new highway could influence where new development occurs, the highway can have a redistributional impact at the regional level, encouraging development to occur along the highway at the expense of other parts of the region. In addition, because the new highway makes it easier to travel via the automobile, it could have a negative impact on other means of travel such as transit.

IMPLEMENTATION: The most difficult aspect of building new highways is often achieving a consensus that such construction is the appropriate course of action. In some areas of the country, voters have overwhelmingly approved the construction of new highways. In others, the decision has been stymied by groups (e.g., transit advocates, environmentalists, nearby homeowners) who feel that new highways are not in the best interest of the community. In most cases, proposals for new highways need to be carefully prepared so that their benefits and impacts can be truly understood, and the ultimate decision should reflect not only the short-term consequences of a new highway, but also the long-term impacts.

Another important aspect of implementation is how the highway construction will be financed. The leeway at the local level in determining where the highway will go and what it will look like is heavily dependent upon the source of funding. If federal or state funds are involved, the design of the highway will likely be directed by design guidelines. If tolls are to be used to repay bonds that were sold to construct the highway, the projected toll revenue amount and timing will likely influence the scheduling of highway construction. (Additional material on highway finance is presented in Chapter 7 of the *Toolbox.)*

Table 4.2-Texas Construction Costs per Lane Mile, 1988 ($ millions)

Class	Cost/Lane Mile
Bridge Replacement	$2.05
Conventional Highway	1.68
Interchange	2.27
New Location Freeway	2.26
New Location Non-Freeway	0.67
Widen Freeway	1.11
Widen Non-Freeway	0.41
Other	0.20
All Construction	0.81

Source: Texas State Department Highways and Public Transportation, Project Development Control Plan, 1988

Differences in costs are reflected in the table of state highway construction cost index, reported in *Engineering News Record:*

California	196.8	Texas	119.3
Colorado	177.1	Virginia	466.1
Florida	185.9	Wisconsin	317.9
Nebraska	148.3		

Source: Hannan, Roger. "Bid Highway Programs Swell Costs." *ENR,* September 15,1988, page 83.

ACTION: Access Control and Management

DESCRIPTION: Highways are classified according to the function they are expected to serve (this **is** referred to as functional classification). The functional classification of highways is in part based on the concepts of accessibility (access to abutting property) and mobility (continuous travel). Access control and management refers to the implementation and enforcement of guidelines that determine the manner in which users will be provided access to a highway facility. Local streets whose function is primarily to serve abutting land uses are designed for accessibility. Freeways and expressways are designed primarily to provide mobility and do so by allowing vehicles on the road only at selected points.

BENEFITS/COSTS: The benefits of having strong access control on a roadway are as follows:

Improve Safety: As development occurs along a highway, more vehicles begin to turn onto and off of that highway to visit abutting shops and houses. The following figures suggest that the accident rate may increase dramatically as the number of intersections and driveways increases along a highway [Ref. 7]:

Intersections per mile	Businesses per mile	Accidents per million vehicle miles
0.2	1	126
2.0	10	170
20.0	100	1,718

Improve Traffic Flow: Controlling access points to a highway minimizes the disturbance to the vehicle flow that occurs when vehicles enter or leave a highway. Thus, highways with access provided at only a select number of points will likely have high vehicle operating speeds and can handle larger volumes of traffic. In the case of highways already having full access control, metering the on-ramps (i.e., allowing vehicles to enter the highway at selected time intervals) can improve traffic flow on the highway.

Prevent Functional Obsolescence: Inadequate control of access is the single largest factor contributing to highways no longer being able to provide safe and efficient movement of vehicles. Good access control can thus save future dollars that would be needed to improve a highway that one day can no longer serve its purpose.

IMPLEMENTATION: Few cities in the U.S. exercise effective access control along their arterial highways. Many restrict driveway width but do not govern the number of driveways that can be provided. Some cities have established policies governing the number of driveways for a single piece of property. A policy specifying the minimum frontages and a corresponding number of driveways for commercial properties is another method to manage access. A number of cities have established uniform driveway standards. A few of these standards, however, fail to recognize the variability of access requirements. Such design criteria should be based on functional characteristics rather than notions of “public” versus “private” access.

A proper implementation of an access control ordinance should regulate (but may not be limited to) the following points:

1. Minimum and maximum driveway width
2. Minimum and maximum curb radius
3. Minimum spacing for driveways
4. Minimum spacing for intersections
5. Allowable number of driveways
6. Allowable intersection angles
7. Grades and sight distance
8. Construction specifications
9. Drainage
10. Inspection and enforcement

References

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ACTION: Geometric Design

DESCRIPTION: The geometric design of a highway consists of all the physical characteristics of the highway that must be considered in the design process. These include horizontal and vertical alignment and clearance, number and width of lanes, shoulders, medians, traffic control devices, bridges, and right-of-way. The engineer uses design criteria that are determined from such factors as design traffic volume, design speed, and sight distance. In most situations, there is not one "perfect design solution." Instead, there are often a number of feasible solutions.

BENEFITS/COSTS: Proper implementation of geometric design standards could result in one or more of the following benefits:

Increased Mobility: For example, increasing the distance to obstructions on both sides of a freeway having two I2 feet wide lanes (in each direction) from 1 foot to 6 feet could increase one measure of mobility (volume/capacity) by about 10% [Ref. 7].

Reduced Construction and Right-of-Way Costs: For example, one possible design of an elevated interchange between two intersecting expressways could be a ramp of 500 feet radius and a design speed of 55 mph. Applying geometric design principles, it can be shown that the two expressways can also be connected by a ramp with a radius of 150 feet and a design speed of 30 mph [Ref. 1]. The construction costs for the second ramp would be about 30% of the cost of the first ramp, while the right-of-way cost for the second ramp could be as low as 10% of the cost of the first ramp.

Increase Traffic Flow: On highways with moderate to steep grades, the design of an additional lane designated as a climbing lane for heavy vehicles will result in increased flow rates for the section.

Improved Safety: For example, in certain cases, an improperly aligned highway with sharp curves may have 5 times as many accidents compared to a highway with good alignment and long straight stretches of road.

Better Aesthetics: Aesthetics of the highway can be planned and built into the design phase of any project. The design and construction by the Colorado Department of Highways of Interstate Highway 70 through the picturesque Glenwood Canyon is testimony to the benefits and importance of aesthetics [Ref. 5]. Another example is provided by several state highway agency programs of planting native wild flowers along state highways.

IMPLEMENTATION: The proper implementation of most aspects of geometric design can be achieved by adherence to the principles and policies expounded in references 1 and 7. However, it is important to understand that the designer must be aware of the relative costs of various levels of design standards versus the present and long-range benefits of the design features that are associated with these standards. Designers should know what a change in design will cost and who will benefit.

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ACTION: Reconstruction

DESCRIPTION: Highway reconstruction is the extensive replacement of roadways that results in increased capacity or structural integrity beyond the design of the original facility. Reconstruction projects include modernizing geometric and structural standards, improving quality of operation and safety, increasing capacity, and extending the life of facilities The elements required for reconstruction projects are basically the same as for new construction, but additional tasks are required for planning and coordinating construction sequences and developing detailed plans that will minimize the disruption to the traveling public.

BENEFITS/COSTS: Reconstruction is a costly and complex activity. However, implementation of reconstruction projects can have a dramatic impact on traffic safety and mobility. It has been noted that in 1984 the nation wasted an estimated 1.25 billion vehicle-hours and 1.38 billion gallons of gas in traffic congestion on limited access highways *(U. S. News and World Report).* Increased capacity, one product of reconstruction, reduces congestion and results in travel time savings. Additionally, reduced congestion improves traffic safety by reducing driver fatigue. Reconstruction also improves safety by reducing vehicle weaving and erratic maneuvers. Reconstruction can also have a beneficial impact on the environment; the increased traffic flow reduces air pollutants by more efficient vehicle operation and by shifting through-traffic from local roads.

IMPLEMENTATION: Successful implementation of reconstruction projects must be done with minimal traffic disruption and generally within existing right-of-way. Construction sequences must be carefully planned and coordinated and planners must be careful to incorporate features that maximize system-wide mobility. In particular, three elements need to be addressed-interchange uniformity, lane balance, and route continuity. Interchange uniformity requires that interchanges along a freeway system assume a consistent operational pattern, i.e., a similar arrangement of exits and entrances at interchanges along the freeway. Lane balance incorporates the basic number of lanes on the system with a proper balance of lanes for exiting and entering traffic. The basic principle requires that for exits the number of lanes on the freeway and ramp after the exit should be one more than on the freeway preceding the exit, and for entrances the number of lanes prior to the merge should equal or be one less than after the merge. Route continuity requires direct and natural paths for motorists through interchanges in order to reduce driver confusion.

ACTION: Traffic Management During Reconstruction

DESCRIPTION: Reducing the costs of delay to highway users during reconstruction projects requires effective planning. Efforts at traffic management can be categorized into two areas: construction enhancement activities and traffic mitigation techniques. Construction enhancement activities involve efforts to speed the completion of the reconstruction project in order to minimize the time period of disruption. This includes the introduction of new materials and/or placement techniques by the construction, contractor and incentives for on-time completion of the construction. Additionally, it may include efforts by the contractor to develop alternative scheduling of construction activities to non-peak periods. Traffic mitigation involves attempts at reducing or effectively managing the congestion resulting from reconstruction. This includes activities such as ridesharing promotions, special parking arrangements, alternative transit services, alternate route traffic flow improvements, intersection improvements, and retiming traffic signals.

BENEFITS/COSTS: The principal benefit of traffic management during reconstruction is the minimizing of traffic disruption. The reconstruction project for the Woodrow Wilson bridge (I-95) in Washington, DC., is a good example of how innovative construction techniques and scheduling minimized traffic disruption. The entire redecking of the bridge was accomplished by using prefabricated slabs lifted into place by a barge moored underneath the bridge. The innovative efforts of the contractor allowed all three lanes to be operational during peak period hours.

The Boston Southeast Expressway is another example of how traffic management techniques aided traffic congestion minimization efforts during reconstruction. Actions implemented included the creation of two contraflow lanes during peak periods, additional park and ride lot capacity, an information brokerage program identifying ridesharing options, signal and pavement marking improvements on alternate routes, expanded mass transit capacity, sponsoring a conference to encourage employers to implement variable work hours, directed police enforcement, financial assistance to local communities for traffic mitigation activities, and a public information campaign. Overall, the efforts resulted in a 9 percent decrease in northbound traffic and a 3 percent decrease in southbound traffic. Average travel time was reduced from 3 to 4 minutes.

A Baltimore, Maryland, highway reconstruction project has also used traffic management techniques to accommodate the 95,000 vehicles a day on the expressway. The number of expressway lanes were reduced from three to two during peak periods. An elaborate alternate route system was developed providing 15 options to arrive in the downtown area. The state highway agency spent nearly $10 million to improve the alternate route facilities. Additionally, $1.2 million was spent on a public relations campaign to inform motorists about the reconstruction project and alternate routes. As a result of these efforts, the number of vehicles per day on the expressway has been reduced by 20,000 to 25,000.

IMPLEMENTATION: Successful implementation of traffic management strategies requires effective and thorough planning and public education. Criteria that can be used to assess the potential effectiveness of individual strategies are documented by Meyer and include:

- Does the strategy provide added opportunity for highway users to use alternative modes or routes?
- Can the strategy be implemented in time?
- Will the strategy be cost effective in terms of dollars spent per level of disruption reduction?
- Will the strategy contribute to permanent transportation improvements after the reconstruction project is finished?
- Can the strategy be terminated if found to be ineffective?

The Edens Expressway Project (I-94) in Chicago and the Parkway East (I-376) project in Pittsburgh document the advantages of effective planning. In Pittsburgh plans were developed to evaluate the effectiveness of the strategies implemented in the first year, and provided for modifications in the second year for implementation of more cost-effective procedures. Without adequate planning, it would have been difficult to identify and implement the modifications in a timely manner.

References:

1. Michael D. Meyer, ‘Reconstructing Major Transportation Facilities: The Case of Boston’s Southeast Expressway,’ Transportation Research Record 1021, Transportation Research Board, 1985.
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ACTION: Street Widening

DESCRIPTION: Street widening can occur in two major ways-increasing the width of existing lanes and adding new lands. Lane width affects driver perception and thus driver behavior, i.e., traveling speed, whereas the addition of new lanes increases the vehicle-carrying capacity of the facility.

BENEFITS/COSTS: Lane width is one of several factors that influences traffic flow. As lane width decreases, the traffic flow decreases, although the influence of lane width becomes minimal at peak hour periods. Widening a road at key locations (e.g. at intersections or where ramps merge onto a highway) can significantly relieve congestion and remove bottlenecks in the highway system. The costs associated with such widening vary according to the amount of land needed and the extent to which other improvements such as signalization are incorporated into the project.

The addition of a lane to a highway does have a significant impact on traffic congestion. Results of studies have shown that the addition of freeway lanes can provide three to four times the benefit compared to costs. These ratios are applicable to about 10 to 15 percent of the existing urban freeway mileage.

The particular influence of lane addition is noted in the following table from the *Highway Capacity Manual:*

Maximum Observed One-Way Hourly Freeway Volumes

URBAN FOUR-LANE Location	Total Volume	Average Volume Per Lane
I-35W, Minneapolis, Minnesota	4690	2345
I-64, Charleston, West Virginia	4152	2077
I-71, Kansas City, Missouri	5256	2628
I-70, Wheeling, West Virginia	3645	1823
I-64, Charleston, West Virginia	3586	1793
I-59, Birmingham, Alabama	4802	2401
I-295, Washington, D.C.	4480	2240
I-35, Kansas City, Kansas	4398	2190
I-45, Houston, Texas	4240	2120
I-55, Jackson, Mississippi	3733	1867
Northern State Parkway, New York	3840	1920
URBAN SIX-LANE Location	**Total Volume**	**Average Volume Per Lane**
I-40, Nashville, Tennessee	6104	2035
I-25, Denver, Colorado	6477	2159
I-495, Prince George County, MD	6993	2331
U.S. 6, Denver, Colorado	6885	2295
California 17, San Jose, CA	6786	2262
I-5, Portland, Oregon	6474	2158
I-15, Salt Lake City, Utah	6357	2119
Southern State Parkway, New York	5610	1870
I-35W, Minneapolis, Minnesota	6909	2303
I-390, Hillside, Illinois	6149	2047

Source: Transportation Research Board. *HIghway Capacity Manual.* Washington, DC.: TRB, 1985.

The observed data indicates that as lanes are added, highways are better able to handle additional traffic.

IMPLEMENTATION: Street widening is generally considered a reconstruction project and thus should be carefully planned to minimize disruption. The widening of a street can also be viewed as an opportunity to correct the deficiencies of the existing road relating to such things as poor geometric design and inadequate access control.

In those cases where disruption to the traveling public is anticipated or where substantial changes to such things as access control are contemplated, efforts must be made to explain what is going to happen to the affected public.

ACTION: Grude Separation

DESCRIPTION: Grade separation is the separation by physical means (e.g., a bridge) of different flows of traffic. Grade separation of vehicles and pedestrians can also be used to reduce congestion and to increase pedestrian safety in urban areas with high concentrations of pedestrian activity.

BENEFITS/COSTS: Inadequate road capacity is the primary cause of congestion in and near intersections. Because two crossing roadways must share a common crossing area (i.e. the intersection), a scheme must be developed to apportion the usage of the intersection to each of the crossing roadways. By removing pedestrians or much of the conflicting traffic from the intersection, grade separation is an effective method for increasing the capacity of an intersection.

Although grade separation is always beneficial in terms of adding capacity to a congested intersection, the means of doing so, that is, the construction of bridges, may be costly due to the cost of construction, right-of-way requirements, and disruption of traffic and businesses during construction.

An alternative to the conventional grade separation structure is a "flyover." These structures can be constructed with minimal disruption to traffic and generally within a fully developed 100 / right-of-way. Three flyovers constructed in Chicago during the late 1950's and early 1960's illustrate the benefits that can be realized from the construction of these grade separation structures:

- Capacity of the three intersections increased an average of 114% to 300%.
- Peak hour flows at nine of the intersection approaches increased an average of 33%.
- Peak hour delay at one intersection decreased from 82 seconds per vehicle to 17 seconds per vehicle, translating into a savings of 80,000 vehicle hours per year.
- Accidents at another intersection decreased from 186 accidents per year to 92 accidents per year.
- A benefit/cost ratio of 2.2 was calculated for one of the intersections.

IMPLEMENTATION: Bonilla provides important criteria that should determine when a flyover is warranted [Ref. 1]:

- The intersection is congested and capacity problems cannot be resolved using conventional traffic engineering methods.
- The roadway is at least four lanes wide and maximum use of the right-of-way has been made.
- The sum of the critical lane volumes meets or exceeds 1200 vehicles per hour
- Obtaining additional right-of-way is not feasible and a minimum right-of-way width of 100' is available.
- The accident rate at the candidate intersection is significantly larger than for nearby intersections along the same arterial.
- Adjacent property is not severely impacted.

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ACTION: Railroad Grade Separation

DESCRIPTION: A railroad grade separation is the result of using a grade separation structure (i.e. bridge) to vertically separate the intersecting highway and railroad. In terms of safety and operating efficiency, a grade separation is the optimum improvement to an at-grade crossing for both the highway user and the railroad.

BENEFITS/COSTS: Construction of a grade separation is a costly endeavor; however, the benefits often more than justify the costs. For example, highway congestion and vehicle delay resulting from the formation of a long line of vehicles while a train is crossing at-grade is completely eliminated. This is especially important for movement of emergency vehicles. Additionally, less fuel is consumed and less pollutants are produced by vehicles idling in the line.

Adverse traffic conditions, such as long lines resulting in unacceptable vehicular delay and congestion, can be a problem on high volume roadways that have at-grade railroad crossings. Vehicles begin to stack up at the intersection, blocking cross-streets and other intersections. Drivers who may select other routes to avoid the at-grade crossing may promote congestion and safety problems on neighboring streets. These effects are compounded when the trains are slow moving and long.

In Austin, Texas, a railroad intersection was converted from an at-grade to a grade separated crossing. The primary reason behind the construction of the bridge was to improve the safety of the crossing which had experienced a number of deaths resulting from automobile-train collisions. However, a secondary benefit was realized in terms of reduced delay to the traffic stream. It is estimated that 22,000 vehicle hours per year were saved immediately after construction in 1983. Today, the estimated savings in vehicle delay based on current traffic counts and train arrival characteristics approach 28,000 vehicle hours per year.

The cost of providing the grade separation during the construction of the roadway should be weighed against the cost of implementing the separation at a later time. For instance, in the Austin example, the cost of building the grade separation concurrently with the mad construction was estimated at $300,000 (1972 $). However, when the structure was actually constructed in 1982, the cost had drastically increased to $2,386,000 resulting in a monetary loss to the city and a 10 year inconvenience and safety hazard to the citizens.

IMPLEMENTATION: The decision to implement a railroad grade separation is primarily based upon engineering judgment. This judgment is guided by several important factors: speeds and volumes of railroad and highway traffic, accident statistics, costs, the number of school buses or trucks carrying hazardous material using the crossing, the existence of multiple tracks which may contain other trains that may block an approaching train from sight, and any other sight specific features that may be regarded as unsafe.

References:

1. Taggart, R.C., et. al., "Evaluating Grade-Separated Rail and Highway Crossing Alternatives," *NCHRP Report No. 288,* Transportation Research Board, Washington, D.C., June 1987.
2. "Railroad-Highway Grade Crossing Handbook," *Report No. TS-78-214,* U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., August 1978.
3. *A Policy on the Geometric Design of Highways and Streets,* AASHTO, Washington, D.C., 1984.

Notes

Photo courtesy of Institute of Transportation Studies, Unrversity of California Berkeley

5 Providing Transit Service

Public transportation is an important element of the transportation system in many cities. For purposes of this *Toolbox,* public transportation is defined as all forms of high-occupancy and shared-ride services. Transit strategies can be divided into three basic types of services: rail/fixed guideway transit (including transitways), bus transit, and paratransit strategies (e.g., ridesharing).

ACTION: Construction of Rail/Fixed Guideway Transit Facilities

DESCRIPTION: There are four major types of transit services in this category: heavy rail, light rail, commuter rail, and transitways.

Heavy rail transit or rail rapid transit is a type of electric transit vehicle railway with the capacity for handling a heavy volume of passengers (20,000-34,000 per hour) and is characterized by operation on exclusive rights of way with multiple car trains, high speed (75-80 mph maximum) and rapid acceleration, sophisticated signaling, high platform loading, third rail power supply and a high degree of automation. Heavy rail systems are often referred to subways, metros or elevated (railways).

Light rail transit (LRT) is a medium capacity rail transit technology that provides passenger capacities ranging from 2,000 to 20,000 travelers an hour. Light rail can operate on either grade-separated, reserved right of way or can operate in mixed traffic on city streets. The latter operation is commonly known as streetcar service. Passenger loading platforms are usually low level and operation is manual. LRT cars can operate singly or in trains and can easily be coupled or uncoupled to adapt to changing traffic conditions.

Commuter rail transit is a service which generally operates between a major downtown and suburban areas of a metropolitan region. Commuter rail operates on mainline rail lines, using high speed locomotives or self-propelled cars in multi-car trains. This service is usually characterized by multi-trip tickets, specific station-to-station fares, railroad employment practices, and usually one or two stations in the central business district.

A ***transitway*** is an exclusive roadway or lane designated specifically for buses and other high occupancy vehicles (HOVs) such as vans and Carpools. Transitways are also known as "busways," "high occupancy vehicle lanes," "bus/carpool lanes," and "commuter lanes." There are four main types of transitways (see page 28):

1. *Exclusive Facility on a Separate Right-of-Way*
   - designated for the exclusive use of buses or other high occupancy vehicles
   - examples: Pittsburgh, PA; Ottawa, Ontario
2. *Exclusive Facility on Freeway Right-of-Way*
   - physically separated from other freeway lanes and for the exclusive use of buses and other high occupancy vehicles.
   - examples: Los Angeles, CA; Houston, TX; Washington, D.C.
3. *Concurrent Flow Lane*
   - in the peak direction of flow not physically separated from other lanes and designated for the exclusive use of buses and other high occupancy vehicles (examples: Los Angeles, CA; Orange County, CA; Alexandria, VA).
4. *Contraflow Lane*
   - a freeway lane taken from the non-peak direction and designated for exclusive use by HOVs traveling in the peak direction (New Jersey to New York).

BENEFITS/COSTS: Heavy rail transit can move large numbers of persons in a fast, efficient and reliable manner. In heavily traveled urban corridors, this is often the mode of choice and offers a very attractive alternative to the motorist. Although heavy rail transit typically requires the highest initial investment cost of all transit modes primarily because of its exclusive grade-separated right of way and large stations, its benefits over the life of the system have been well documented in numerous studies of heavy rail systems throughout the world.

Light rail transit construction savings are significant over those of heavy rail transit systems because of light rail transit's ability to use all types of right of way. Unlike heavy rail, light rail transit may avoid costly tunneling or elevated construction. However, there is a distinct tradeoff in terms of passenger carrying capacity. Heavy rail systems are most appropriate for highly dense corridors, whereas light rail is considered to be a medium capacity service.

Commuter rail services can be the least costly high capacity rail services to implement because they operate on existing mainline rail lines. Typically, commuter rail services have very heavy peak hour service with little or even no off peak service. Because these services often handle "the peak of the peak," they reduce the need for investment in plant and equipment to handle a peak load by another mode, either highway or transit. Because under-utilized railroad track exists in many places, it is often possible to run a few peak hour trains by adding only locomotives, cars and labor. Therefore, commuter rail services can become a very attractive alternative for public agencies seeking to connect suburban areas with central cities.

A transitway lane typically will carry three times more people during the peak hour than an adjacent freeway lane. For example, the Katy Transitway in Houston with one lane carries almost the same number of commuters as the three adjacent lanes during the peak hour. Tmnsitways offer significant travel time savings compared to adjacent freeway lanes. Transitway users experience more predictable travel times than other freeway users. Surveys show that 35 to 50% of transitway users are “new” to transit and Carpools. Increased HOV use reduces the need for new highway construction, saves energy, and reduces pollution. During the peak hour, 18,000 residents use the Ottawa, Ontario, transitways.

Tmnsitways are often less costly than other traditional alternatives for gaining significant increases in capacity. Independent segments can become operational as funding becomes available and construction of the segments are completed. Tmnsitways can achieve increased capacity while maintaining rights-of-way in advance of additional capacity improvements such as rail development.

In addition to the benefits mentioned above, there is some evidence to suggest that investments in fixed guideway transit can influence development patterns, improve air quality through reduction in exhaust emissions, and provide for more efficient utilization of energy resources.

IMPLEMENTATION: Discussed later in this chapter (p. 92).

References:

1. *APTA Rail Transit Report.* American Public Transit Association, September, 1987.
2. *APTA 1988 Transit Fact Book,* American Public Transit Association, Research and Statistics Department, August 1988.
3. *Urban Public Transportation Systems and Technology,* Vukan R. Vuchic, University of Pennsylvania, 1981.
4. *Light Rail Transit,* American Public Transit Association, September, 1987.
5. *Urban Rail in America; An Exploration of Criteria for Fixed Guideway Transit,* Boris Pushkarev and Jeffrey Zupan, Regional Plan Association, November 1980, U.S. DOT report no. UMTA-NY-06-0061-80-1.
6. *Transitways.* Washington, D.C. : American Public Transit Association, October 1987.

[Reports of the American Public Transit Association can be obtained from APTA, Information Center, 1201 New York Avenue, N.W., Washington, D.C. 20005, (202) 898-4000.]

ACTION: Implement Fixed Route and Express Bus Services

DESCRIPTION: Basic transit services for millions of passengers are provided each day by over 74,000 buses operating in large cities, towns and rural areas. Such service is provided in two ways-fixed route and express bus services.

Fixed Route Bus Service: Fixed route bus service is provided on a regularly scheduled basis along a specific route with buses picking up and discharging passengers at the same locations each time they traverse the route. Fixed route bus service, using 35-40 foot vehicles to provide service, is the most prevalent type of transit service in use today. Although the industry has relied greatly on the standard 35-40 foot motor bus and fixed route service, an increasing variety of vehicle designs and services have been developed to meet particular needs and new markets.

Smaller buses (less than 28 feet in length) down to l0-passenger vans are now being used by some transit agencies to provide fixed route transit service in areas where full size buses are not required but where regularly schedule service is still needed. Many of these services are located in areas where mad conditions would make access by standard transit buses difficult and where ridership levels can be easily accommodated with smaller vehicles. Some services operate during nights or weekends when ridership demand is lower. On the other hand, articulated buses are used in many large urban areas on transit routes with heavy passenger demand. These buses are 55 to 60 feet in length and have two connected passenger compartments able to bend at their connecting point when the bus negotiates a corner. Effective transit services in suburban settings will require routings that reflect the growing dominance of crosstown trips. Radial, downtown-oriented routes may need to be converted to grid networks that operate out of timed transfer points.

Express Bus Service: Express service is a variation of fixed route service where a portion of the route is operated without stops or with a very limited number of stops to pick up or discharge passengers. This service strategy is particularly attractive to commuters in outlying suburban areas who desire fast service to downtown areas. When used in conjunction with preferential treatment for buses or exclusive busways, express bus service becomes extremely competitive with the auto because it offers substantial travel time savings.

BENEFITS/COSTS: Buses are the most flexible form of transit. They can be re-routed and/or rescheduled quickly to meet changing rider-ship demand. They are more appropriate for diffuse trip patterns, since individual routes can be set up for different groups of trips. Maintaining or increasing service in existing corridors requites minimal effort administratively. The major constraint will be an increased operating budget to hire drivers for the peak demand periods.

Because of the variation in equipment size from 25 passenger small buses to articulated buses which can carry 67 seated and 32 standing passengers, equipment can also be changed as demand changes. In fact, many transit agencies have a fleet consisting of several types of vehicles to accommodate such needs. Smaller buses tend to be used for transporting elderly and disabled persons or in suburban areas where demand is lower and where roadway geometry does not accommodate full size buses. On the other hand, articulated vehicles are typically used on high ridership line haul routes.

If buses are given priority treatment on existing roads and streets, buses can provide higher levels of service. However, where buses are operating on reserved lanes (transitways or high occupancy vehicle lanes), they lose their flexibility. Flexibility can be a disadvantage if one of the purposes of building a transit system is to encourage denser land use development patterns.

The primary benefit of timed transfer operations is an improved route structure. Feeder routes, that are oriented to another rail or bus network, are replaced with route designs that directly link non-CBD activity centers. Capital costs are necessary though, whereas route changes on feeder lines only require new maps.

Timed transfer operations must be instituted with care. They require radical changes in schedules and routes, and therefore could discourage passengers at first. Also, the construction costs are high, and operating costs could be high if big rider increases are needed to break even financially. Nevertheless, these operations may possibly be the best response to suburban market demands that employs fixed-route service.

IMPLEMENTATION: Discussed later in this chapter (p. 92).

References

1. *Suburban Gridlock,* Robert Cervero, Center for Urban Policy Research Press, Rutgers University, New Brunswick, New Jersey. 1987.
2. "Planning and Designing a Transit Center-Based Transit System: Guidelines and Examples from Case Studies in 22 Cities." Department of Civil Engineering and Urban Planning, University of Washington, Seattle. Prepared for USDOT & UMTA. September, 1980 (DOT-I-81-5)
3. "Service Criteria and Performance Guidelines for Fixed Route Service." Pace Suburban Bus Division of RTA, 550 West Algonquin Road, Arlington Heights, Illinois 60005, (312) 364-7223. ,

ACTION: Implement Paratransit Services

DESCRIPTION: Paratransit services encompass almost any type of service that is not rail/fixed guideway or fixed route bus services. Such services include carpooling, vanpooling, subscription bus, shared-ride taxi or route-deviation services. While conventional fixed-route (or fixed guideway) transit services play an important role in providing line haul service in higher density corridors, highly dispersed travel in lower density areas is often best served by paratmnsit options.

Two major categories of paratransit strategies described below are demand-responsive services and ridesharing.

Demand-Responsive Service

Demand-responsive services generally operate on a flexible schedule, as opposed to ridesharing which generally involves a regular, pre-arranged trip. Demand-responsive transit typically offers door-to-door service utilizing small buses or vans. Some transit systems provide demand-responsive service nights, weekends, and/or off-peak hours when higher capacity service is not required. This strategy is also used to provide door-to-door or curb-to-curb service to elderly and/or handicapped riders who have difficulty walking to a rail station or bus stop. Smaller communities also rely more heavily on demand-responsive services than do larger urban areas.

Ridesharing

Ridesharing takes three major forms-Carpools, Vanpools and subscription bus services. A description of ridesharing actions is found on page 117.

IMPLEMENTATION FOR PROVIDING TRANSIT SERVICE

Land Use and Density Conditions

Transit service works best when tailored to the types of land use and the density of population, employment and commercial development in the areas it serves. Density of development affects the extent to which transit is used. Higher densities, in the range of 4,500 population/ employment per square mile, lead to increased ridership. This holds true for higher densities at the "origin" end of the trip (the home) or at the "destination" end (place of work, shopping, etc.); either way, transit use is enhanced by higher densities.

Transit ridership is also impacted by the type of land use. Land use affects the types of transit trips that are taken and the days of the week and times of the day of these trips. For example, office employees who work typical business hours (9 a.m. to 5 p.m.) have different travel requirements than hospital employees who work rotating shifts.

Cost effective transit service can be designed to serve areas of both high and low density as well as various types of land use. The following guidelines can be used to assess the initiation of transit service. They represent general observations, not hard-and-fast rules. The guidelines are keyed to land use and are based on both residential densities (dwelling units per acre) and non-residential floorspace. The particular arrangement of these land uses within an area-how evenly spaced, whether they are continguous, how closely aligned in a particular potential transit corridor-will affect the suitability of particular transit options. It must be kept in mind that it is always possible and sometimes desirable, as a matter of local policy, to provide transit services where travel demand may be below these general thresholds.

A minimum level of local bus service (20 daily bus trips in each direction or one bus per hour) is often provided in residential areas averaging 4 to 5 dwelling units per acre. Typically, these residential densities correspond to gross population densities of 3,000 to 4,000 people per square mile. This level of bus service is suitable for non-residential concentrations of activities in the range of 5 to 8 million square feet of floorspace, occasionally lower.

An intermediate level of local bus service (40 daily bus trips in each direction or one bus every 1/2 hour) is often provided in residential areas averaging 7 dwelling units per acre (5,000 to 6,000 people per square mile) and for non-residential concentrations of activities from 8 to 20 million square feet.

A frequent level of local bus service (120 daily bus trips in each direction or one bus every ten minutes) is often provided in residential areas averaging 15 dwellings per acre (8,000 to 10,000 people per square mile) and for non-residential concentrations of activities from 20 to 50 million square feet.

Once we move into the range of land use activities found in the frequent level of service range, the speed of bus service tends to decline rapidly due to on-street congestion, and more frequent pick up/drop off of passengers. If routes are of considerable length, the attractiveness of such slow service can decline rapidly as well. Thus, at non-residential concentrations in the 20 million square foot range and above faster transit service is called for. One way of achieving this without resorting to different technology is to create express bus service, thereby avoiding local traffic. Such service can be further speeded up if exclusive rights-of-way are provided.

Express bus service can operate in two distinct ways. If the express bus route circulates in a residential area with most riders accessing the bus by walking to bus stops, the bus will suffer from added costs because of the added operator time involved and lower revenues because the service will not be as attractive to the potential rider. If the express route boards riders at only a few designated locations-with park/ride lots to promote concentrated pick-up points-the service may be more attractively operated from both the operators' and riders' perspective.

Light rail transit is most suitable for service to non-residential concentrations of 35 to 50 million square feet. If rights-of-way can be obtained at grade, thereby lowering capital costs, this threshold can be lowered to the 20 million square foot range. Average residential densities of about 9 dwelling units per acre over the line's catchment area are most suitable. For longer travel distances where higher speeds are needed, rapid transit is most suitable for non-residential concentrations beyond 50 million square feet and in corridors averaging 12 dwelling units per acre or more.

Commuter rail service, with its high speed, relatively infrequent service (based on a printed schedule rather than regular headways) and greater station spacing is suitable for low density residential areas-l to 2 dwelling units per acre. However, the volumes required are only likely in corridors leading to non-residential concentrations of 100 million square feet or more, found only in the nation's largest cities.

For paratransit service modes activity levels and densities lower than the thresholds described above are likely to be more suitable. These modes often depend less on the particular land use pattern found in an area and more on the initiatives of the affected parties. For example, any four people working near one another (usually at the same site for the same employer) can establish a carp001 if they wish. They would do so to share the cost and burden of driving every day. But for more widespread use of Carpools and vanpools an institutional initiative on the part of an employer would probably be required, motivated by the desire to see congestion relief on approach roads to their facility or for the reduced parking requirements that may result. A factor which may often work against carpools is the need for flexibility in start and leave times and availability of transportation during working hours for personal business, lunch or emergencies. Compatiiility with fellow poolers is likewise important (more so for carpools, less for subscription buses). More widespread use is also held down by the time it takes to gather parkers at a common point or points at the residential end of the trip. This can be a particular problem for Vanpools and subscription buses, limiting their applicability to longer distance trips where the "gathering time" is proportionately less significant. Still these modes can be effective, particularly if institutional support is present from large employers with many persons working at one site with identical (and regular) working schedules.

Urban Form and its Impact on Transit Services

The pattern of development has a major impact on the type of transit service offered and its location. Transit works best when density of development occurs linearly along a corridor, with heavy trip generators located at either end of the corridor, and other generators spaced along the corridor's entire length. Transit is most efficient when residential and employment land uses both are found at each end of the corridor. This allows the transit vehicle to carry balanced loads in both directions of travel. Locating other travel generators at intermediate points along the corridor allows patron boardings and alightings to occur throughout the transit vehicle trip, thereby improving service productivity and minimizing vehicle crowding.

When development patterns are more dispersed, transit service can be provided in two basic ways. The first way is to provide local service between particular nodes of development and the surrounding residential areas. This collector type of service is typically supplemented by direct, express-type service that connects the nodes together. The second way is to provide a grid of transit services that cross in a perpendicular fashion on the street network. This allows patrons to travel theoretically from one point to any other point in the area with no more than one transfer.

Where Highway Options are Limited

Many times development patterns and/or land use constraints limit the construction of new or expanded streets and highways. Fixed guideway transit facilities are good options to consider in such areas. Rail facilities and exclusive busways can move tens of thousands of riders per hour within narrow rights-of-way. These fixed guideways can also be built in congested downtown areas as subways under existing streets.

Transit options can also be used to greatly enhance the people-carrying capacity of existing highways. Converting a mixed traffic lane into a bus lane can not only increases capacity of the roadway, but also decreases rider travel times and removes slow-moving buses from congested adjacent streets. Preferential transit treatment can enhance the entire street system.

Transit Service Availability and Level of Service

Trip-makers consider a number of factors in deciding which mode to use when they want to make a particular trip. Availability of service is the first factor considered by the traveler. Availability can be determined by answering the question: Does transit service exist within a convenient distance from the original destination of a rider's desired trip? "Convenient" to a transit planner normally means a distance of about 1/4 to 1/2 mile. Obviously each rider makes his or her own judgment about distance. Transit dependent riders who have no automobile available will tolerate greater distances than those who have a choice. Senior citizens may be willing to walk only short distances. Transit access distance is an especially critical factor for wheelchair users and other disabled persons.

Level of service is another important factor in determining choice of mode. Level of service takes into account two considerations: the number of transit vehicles that the traveler can take to get to his/her destination, and the times that the transit service is available. Higher frequencies of transit service, and convenient hours of service, make transit more attractive to the user.

Travel Time

Travel time is an important determinant of transit use. All things being equal, people will choose the mode which will get them to their destination fastest. Travel time is usually spoken of in terms of travelers' "door-to-door" time. This is the time when they leave their home or other point of origin until they arrive at their final destination. On transit "door-to-door" time includes the time traveling to and from transit stops and the time spent waiting for the transit vehicle.

Cities with rapid transit provided **on** separate rights of way can offer faster line-haul service for their residents than the automobile. The keys to providing improved travel times on transit are fast running times, quick and convenient transfers, (or no transfers) and frequent service.

Parking Costs, Parking Availability, Tax Law Effects

The availability of free or low-cost, employer subsidized parking at the workplace makes it difficult for transit to compete with the automobile for many trips. Conversely, as is found in many central business districts, the higher cost of all-day parking makes transit very competitive and results in higher transit utilization.

Employer subsidized parking is an employee benefit that is not subject to federal income taxes. By contrast, provision of a monthly transit pass for employees is considered to be taxable income when it exceeds $15 per month.

This creates an advantage for use of the automobile over transit. Similarly, shopping centers and malls provide hundreds of free parking spaces for shoppers as well **as** employees compared often with little or no support for transit service.

Transit Pricing

The price of riding transit, as defined by the fare that is paid by the transit rider, is another determinant of transit use. Fare levels are generally related to the quality of service, the quantity of service and the cost of providing service. As for almost any consumer activity, transit use is elastic with respect to pricing. That is, as the price increases, the amount demanded (ridership) decreases.

A number of factors are used in determining how fares are structured and fare levels set. These factors are used for purposes of convenience, equity and market segmentation, as well as to respond to elasticities. These fare types include distance pricing (zone fares), time of day pricing (peak hour fares), quantity discount pricing (weekly and monthly passes), and fares by passenger type (adult, child, senior citizen).

Various levels of government provide transit subsidies to stabilize fares and to maintain and increase transit ridership. Adequate and predictable amounts of funding, whether from fares, subsidies, or other sources, are critical to the continuation of viable transit service.

Reliability/Convenience/Comfort/Safety/Security

These five factors not only influence mode choice, but play an important role in the traveler's decision to continue to travel by a particular mode. It is likely that availability, level of service, travel time and cost are the factors that are first considered in choosing a mode. However, the selected mode must also be reliable, convenient, comfortable, safe and secure, if the user's patronage is to be retained.

As applied to transit, these five factors are defined as follows:

Reliability	Adherence to published schedules. Known as on time performance; typical measure: no more than 5 minutes late/2 minutes early.
Convenience	Nearby, frequent service with good public information which is readily available, and which has an easily understood and utilized fare structure.
comfort	Vehicles that are comfortable to ride.
Safety	Operation of transit service that is free from crime.

These secondary factors must at least meet minimum expectations to first capture, then retain each transit rider.

Site Design Characteristics

New developments, whether office, commercial or residential, need to be physically designed with transit in mind. Too often they are not. This means that site access roads must be able to handle transit vehicles in regard to vehicle weight and turning requirements, and with respect to pedestrian and transit rider needs. There have been many cases of developments, particularly in suburban areas, that in a time have grown large enough to generate substantial transit ridership but which could not be well served due to site design constraints.

Site location is another important and related criterion. Sites that are physically isolated from available transit service, whether by distance or due to a physical barrier, are difficult to serve even though they may be large enough to generate substantial potential transit use.

ACTION: Land Use Policies for Improved Transit Access

DESCRIPTION: This action establishes a land use policy which promotes transit use in order to reduce and or mitigate congestion and other consequences of burgeoning travel demand. Such policies encourage construction of public transportation facilities and are formalized in zoning/planning regulations and procedures.

Residential and employment densities of different levels produce unique travel patterns. Higher densities, in the range of 4,500 population/employment per square mile, increase the likelihood of success for transit services.

Residential densities of at least seven dwelling units per acre are considered necessary to economically justify use of local bus routes operating 30 minute headways. As residential density rises to 30 dwelling units per acre, transit use has been found to triple and at 50 units per acre becomes more numerous than auto trips. Likewise, transit ridership increases significantly as employment density exceeds approximately 50 employees per acre or in activity centers having more than 10,000 jobs [Ref.1]

At lower densities, the opportunities for providing transit service in the future should be maintained. Growth management and designs for open space hold great potential for future transit compatible development.

BENEFITS/COSTS: In the text of an ordinance adopted by the City of Alexandria, Virginia in 1987, the impact of increased traffic is stated to be "contrary to the public welfare." Parking excesses, air pollution, and wasteful energy consumption are cited as the costs of inaction with regard to a land-use policy that has overlooked the effects of traffic congestion and failed to consider the benefits of a balanced transportation system.

The major benefits of coordinated transportation and land use planning are:

- higher transit rider-ship and auto occupancy,
- lower transit operating costs,
- improved access for transit vehicles, and
- increased financial support for public transportation through public-private sector partnerships.

Local jurisdictions benefit through:

- Reduced demand on roadway capacity;
- Improved access to activity centers and greater mobility for residents;
- Reduced parking needs; and
- A more pedestrian-oriented environment.

Benefits that can be realized by the private sector when public transportation is considered in the initial design stages of a new project include:

- Reduced parking needs, which translate into cost savings;
- Greater marketability of the project;
- Fewer delays in the development review process, with attendant cost savings; and
- Increased chance of project approval.

There are also benefits to the public. These include:

- Higher levels and quality of service within a fixed budget;
- More transportation options; and
- Environmental benefits.

IMPLEMENTATION: A few standard rules govern the application of a pro-transit land use policy:

- ***Transit services should be designed in advance of development*** to ensure that streets/walkways feed into transit corridors and generate peak period commuters.
- ***New developments should be located within already established areas.***
- ***Mixed-use activity should be encouraged.*** Where possible, both housing and employment centers should be provided in close proximity.
- ***Standard size design criteria should be applied***. These include: minimal walking distances to transit corridors; buildings oriented to the street with parking in the back rather than the front; provision of sidewalks, bus stops and bus turnouts, etc. (see site design criteria section).
- ***Parking should be controlled*** in terms of pricing, availability and location and single-occupant auto trips should be discouraged (see parking section).

A growing number of land use guidelines and model ordinances are being adopted which favor transit use. Transit compatibility and insuring densities which support transit in new developments was the objective of formal guidelines established in 1980 by the Regional Municipality of Ottawa-Carleton, Ontario, Canada. The guidelines call for site design controls and require that transit be included from the outset of a project. A level of flexibility is built in that sets unique conditions for each development. Also focused on new development, but at the other end of the requirements spectrum, is the City of Alexandria's congestion ordinance. Passed in 1987, it requires approval of a transportation management plan (preferably one that is oriented to transit) for all new developments over a specific size, ***with special use permits to follow.***

Land use policies in high-density areas must be adhered to in order to sustain transit ridership. In European cities where land patterns were established centuries ago, sprawled suburban development is strictly prohibited, and high-density clustered development is strongly encouraged. European land policies encourage people to seek alternatives to the auto, an effect that is reinforced by subsidy.

A range of pro-transit zoning and development control measures are available including: planned urban developments, floating zoning, special districts, mixed-used zones, land banking, traffic impact fees and development exactions.

References

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2. "Guide for Including Public Transit in Land Use Planning. (1983)" Alameda-Contra Costa Transit District, 1600 Franklin Street, Oakland, California. 94612, (415) 891-4777.
3. "Transit Servicing of New Residential Areas: Guidelines for Development (August 1980) ." Transportation Department, Regional Municipality of Ottawa-Carleton, 1500 Saint Laurent Boulevard, Ottawa, Ontario, Canada, K1GOZ8, (613) 741-6440.
4. Code of the City of Alexandria, Chapter 6, Title 7, Article R, Transportation Management Special Use Permits. Alexandria, Virginia. May 1987.
5. ***Public Transportation and Land-Use Policy,*** B. Pushkarev and J. Zupan, Indiana University Press, Bloomington, Indiana, 1976.
6. "Consideration of Transit in Project Development" (1988), Orange County Transit District, P.0. Box 3005, Garden Grove, California, 92642-3005. (714) 971-6200.

ACTION: Site Design Criteria that Increase Transit Usage

DESCRIPTION: Site design criteria can mitigate traffic congestion by incorporating transit access. Local officials should insist that basic site design analysis be conducted for each proposed development that tests alternative site plans for public transportation accessibility.

Pro-transit site design criteria for new housing and office developments include

- ***Place office buildings in close proximity to the street,*** resulting in easy pedestrian access rather than being separated by parking.
- ***Minimize walking distances*** between homes and transit routes.
- ***Minimize block lengths*** in business districts.
- ***Sidewalks*** on at least one side of each street.

- ***Provisions for bus stops*** and passenger shelters.
- ***Maximize street geometrics*** for use by transit vehicles.
- Streets identified for transit routes should be ***structurally capable of supporting the weight of buses.***
- ***Parking should be controlled.***

BENEFITS/COSTS: Site design and physical improvements in the initial stages of new developments are two of the easiest ways to build in operating cost savings for the transportation system.

Bus turnouts constructed every two blocks on a residential collector street and streets built for heavy-duty use have significant costs. The price is small, though, compared to lost travel time and ongoing enforcement costs of clear intersections over the life of the roadway.

Strategically located bus-turnarounds are critical to maintaining on-time transit performance. Regarding geometrics, two circumstances greatly limit bus turning movements which slows traffic to a crawl: autos parked too close to intersections, and intersections with narrow lane widths.

IMPLEMENTATION: In growing areas committed to regular fixed route transit, a major commitment must also be made to work with local officials and developers to adopt site design standards. METRO in Seattle, Washington and AC Transit in Oakland, California, and the Orange County Transit District in California aggressively promote a specific set of design criteria throughout the planning process.

The two most common destinations in growing areas, office parks and shopping centers, should be targeted for transit reforms. Surveys of these centers show that few have transit drop-off zones or shelters. Moreover, the average walking distance from the main building to the nearest bus stop is four times the distance to the middle of the parking lot. Some surveys indicate that buses are excluded from these facilities because of image concerns.

Designs that support fixed-route transit may be difficult to implement in suburban areas due to prevailing architectural and zoning standards for parking and landscaping. Low-density site designs have resulted in isolated, campus-like office settings in suburbs such as Schaumburg or Oak Brook, Illinois. The best response in this situation may be to promote non-traditional transit forms (such as dial-a-ride, van-pools or subscription bus) until development philosophies reverse, and/or densities start to increase and suburban centers become more like central cities.

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4. "Geometric Design Standards for Lane Widths, Bus Turnouts, Bus Turnarounds and Intersection Radii" and other sections of ***Transit Facilities Standards Manual,*** Alameda-Contra Costa Transit District, 1600 Franklin Street, Oakland, California, 94612, (415) 891-4777.
5. "Unlocking Suburban Gridlock." Robert Cervero, American Planning Association Journal, p. 389-406. Autumn, 1987.

ACTION: Transit-Oriented Parking Management Strategies

DESCRIPTION: The linkage between good site access and economic activity is powerful. Thus careful, almost scientific attention is required to induce parking interests (developers, lenders, employers, employees, shoppers) into considering utilization of parking management strategies which favor alternatives to the single occupancy vehicle.

A parking management strategy that encourages more transit usage would include the following features:

- ***Coordination with zoning, planning and public works authorities*** whenever a proposed action or development that includes parking will affect traffic volumes:
  - ***On-street parking supply.*** Policy should promote residential area permits and preferential parking for Carpools, and should discourage block closings.
  - ***Off-street parking supply.*** Policy should give incentives for providing direct access to transit facilities, and for establishing car pools. It should set strict limitations on parking quantities in a given area.
- Pricing. Elimination of free parking will discourage solo driving. Tax exemptions should be sought for allemployees-auto commuters and transit users alike.
- ***Fringe parking.*** Promote part-and-ride lots.
- ***Parking*** reduction ***legislation*** to create ridesharing incentives.
- ***Transit marketing to*** counter ***negative perceptions.*** CBD parker surveys indicate that solo trips are preferred to perceived unpleasant aspects of transit-slow travel, safety concerns, crowds.
- ***Maximize use of existing parking facilities*** used for transit purposes. It should be emphasized that this strategy is aimed at encouraging transit use and could conflict with other parking program objectives (see Parking Management, page 52).

BENEFITS/COSTS: Provision of fewer parking spaces translates into more efficient use of space as parking takes up space that could be used for employment , housing and tax revenue generation. Limiting parking also results in reduced traffic road and maintenance costs since more parking generates more traffic, increasing the costs of maintaining and providing roads. Finally, aesthetic gains are achieved from less asphalt and more open space and landscaping opportunities.

Parking reduction ordinances allow developers the option of providing fewer parking stalls. Such laws have the potential of increasing ridesharing, and increasing construction cost savings to developers. Cost savings per parking space eliminated can range from $1,000 to more than $15,000 depending on land costs and type of parking facility. But incentives often go unused-building one space per employee is still perceived to be financially less risky in the long-term than a carpooling program. Also, lending institutions often show a bias towards provision of parking lots in the interests of tenants.

IMPLEMENTATION: Employer parking policies should be carefully examined by transit policy makers. When parking is provided free of charge, it encourages more single occupant drivers. However, any campaign to reduce free parking at the job site must be coupled with travel alternatives including both transit and ridesharing efforts. The program operated at the corporate headquarters of Atlantic Richfield Company (ARCO) in Los Angeles produces a 56% ridesharing result among employees. ARCO offers graduated parking discounts, rising to a 100% reduction for 3-person Carpools.

Regarding parking quantities in built-up areas, low maximum thresholds for parking space provision could have the undesirable effect of discouraging potential developers. Parking constraints must be applied in a manner that results in no loss of jobs. The City of Chicago grants reductions in the amount of required parking where there is adjacent transit access or pedestrian tunnels. Sacramento has included parking reduction features in its zoning in exchange for the provision of on-site bicycle facilties, purchase of transit passes for employees, and for establishing ridesharing programs.

Remote parking lots should be located at distances appropriate to the particular environment considering parking availability and level of congestion. Unless parking supply is restricted, park-and-ride lots should be constructed or leased near the origin-end of the trip. The availability of park and ride lots is critically important to the success of fixed guideway systems. Good local road access to the lots is also critical. Congested access roads to these lots will deter "choice" riders from using fixed guideway systems. Finally, successful park-and-ride operations also depend heavily on transit service frequency from the lot. A minimum of 10 minute headways (or service intervals) in the peak period are required, as well as regular mid-day service.

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3. "Parking Management Tactics" Vol. l-3. Peat Marwick Mitchell & Co. for FHWA, Washington, D.C. June, 1981.
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ACTION: Employer Initiatives that Encourage Transit Use

DESCRIPTION: Employers can implement four major types of initiatives to reduce congestion.

1. ***Encourage ridesharing, Carpools and Vanpools.*** A wide range of model programs exist for different company sixes and commuter distances.
2. Take advantage of legislation that allows ***tax write-off for employee transit subsidies*** Tax laws permit $15 per month, per employee for transit passes. While this does not yet equal the long-standing tax allowance for employee parking, efforts are underway to bring the two tax breaks into balance.
3. ***Institute flex-time programs*** that allow employees to spread their arrival and departure times throughout the peak periods of the day. Large employers have the greatest impact on congestion and therefore will benefit the most from such programs.
4. ***Participate*** in ***Transportation Management Associations.*** TMAs have been described as "an association of from 5 to 75 employer members that engage in a wide range of activities, such as promoting ridesharing through computerized matching services, purchasing fleets of vans for employee pooling, assisting members in meeting government trip reduction mandates, underwriting internal shuttle services and park-and-ride circulators, financing area-wide street improvements such as signal upgrading, and even planning long-range transportation projects such as rail transit extensions," TMA's are prevalent in high growth metropolitan areas where traffic conditions have reached critical proportions.

BENEFITS/COSTS: If one out of five drivers of single occupant vehicles decided to rideshare, peak period traffic would decrease 18 percent. While the direct costs of ridesharing are much less than driving alone, it requires a high degree of organization initially and sustained participation.

Flex time is a relatively low-cost strategy for companies. Switching arrival times by 15 to 30 minutes can reduce the passenger volumes at rail stations and intersections by as much as 15 percent.

IMPLEMENTATION: Ridesharing programs are becoming an important element of the transportation system. Area programs can be centrally organized or centrally coordinated, and easy for employers to tap into. Seattle is typical of this arrangement, where the Seattle Engineering Department and the local transit agency (Metro) manage two coordinated carpooling programs. Each administers parking lots and downtown on-street parking zones held exclusively for ridesharing.

The tax code now provides an employer with a more powerful tool than ever to promote transit usage. The $15 per employee per month tax write-off is allowed in the same fashion that tax credits are provided for parking expenses. A unique program in New York City called "TransitCheks" was created as a simple, comprehensive approach to the subsidy. Administered by a region-wide office, TransitCheks can be distributed to employees, who in turn redeem them for 15 subway or bus tokens at designated token booths, or $15 discounts on the purchase of tickets or passes.

References:

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Notes

Photo by Ron Delany, courtesy of Institute of Transportation Studies, University of California, Berkeley

6 Managing Transportation Demand

In its broadest sense, demand management is any action or set of actions aimed at reducing the impact of traffic by influencing people's travel behavior. A comprehensive demand management strategy involves:

- One or more alternative transportation modes and/or services;
- A set of incentives intended to induce commuters to shift to the alternative modes and/or services;
- Growth management policies designed to maintain a balance between transportation demand and transportation facilities;
- An implementation mechanism

Demand management can focus on short-term actions designed to ***mitigate*** existing congestion problems, or on more strategic approaches to avoid future congestion. Available evidence suggests that well-conceived and aggressively promoted demand reduction programs can indeed decrease peak period traffic over the short-term by as much as 10 to 15 percent. But one should be careful to understand the limitations of this technique. Demand reduction efforts, unless undertaken on a truly massive scale, can have only a local impact. They can relieve spot congestion-for example, at entrances and exits to large employment centers-but they cannot appreciably reduce traffic on freeways and major arterials. This is not to say that traffic mitigation programs ate not worth undertaking. However, one should be careful not to raise unrealistic public expectations as to their impact on areawide levels of traffic congestion.

Strategic Approaches to Avoiding Congestion

ACTION: Growth Management

DESCRIPTION: Growth management can be defined as the use of public policy to regulate the location, geographic pattern, density, quality and rate of growth of development. By knowing the trip generation characteristics of various land uses and then exercising control over those uses one can theoretically limit the trip generation of a particular area to any given level. This level would be consistent with the capacity of the existing infrastructure and the level of service desired. A comprehensive gmwth management strategy can include not only transportation actions, but also actions dealing with housing, economic development, open space, and community infrastructure. Three growth management examples follow:

- **Montgomery County (Maryland) Adequate Public Facilities Ordinance**

  The County Council enacted the Adequate Public Facilities Ordinance (APFO) in 1979. The law is quite simple:

  > "New subdivisions may not be approved unless the Planning Board determines that there will be adequate public facilities to support the development ."

  The Planning Board has the authority to withhold subdivision approval if existing roads, plus new roads, plus transit scheduled to be completed in the capital improvements program will not satisfactorily handle the additional traffic from the proposed subdivision plus traffic from existing and previously approved development. In essence, the APFO allows the County to delay new development until “adequate" transportation facilities are in place. The law, however, does not give the County the right to prohibit development that is consistent with the master plan. An elaborate technical process, involving sophisticated predictive techniques and allowing credit for demand management actions, is used to determine whether the facilities are “adequate.’ ' However, even if the transportation facilities fail to meet the test of adequacy, a developer may still be able to obtain approval to build if he commits himself to implementing a “trip reduction program” and is able to document concrete traflic reductions (see “Negotiated Demand Management Agreements”).

  The County is divided into 15 travel sheds called “policy areas,’ ' which are classified into five categories of allowable traffic congestion. In the southern portion of the county, where development densities are high and transit service is extensive, higher levels of traffic congestion are allowed before the policy areas' road capacity is deemed “inadequate.” In the less urbanized portions of the county, where transit service is poor or non-existent, lower levels of traffic congestion are allowed. Each year, the traffic generated by existing and approved development is simulated on a network of existing and programmed transportation facilities to determine whether the threshold level of service will be met by each policy area. If the forecasted congestion is worse than the standard in a policy area, no more development can be approved through the subdivision process until more capacity comes on line. If the simulated level of service is higher than the standard, then the proposed development must still pass a second step-the “local area review” test-which determines whether the intersections in the immediate vicinity of the development will be no worse than LOS E in the peak hour with the development in place.

- **City of Irvine, California/Irvine Business Complex Ordinance**

The Irvine Business Complex is located on the western edge of Irvine, near John Wayne Airport, The complex occupies 2,500 acres, and is the largest such complex in Southern California. Although originally zoned for industrial uses, the area has experienced intense office development, which generates about three times as much traffic as the original road system was designed for. The City of Irvine calculated that the roadway system with planned improvements could accommodate an additional 15 million square feet of office space.

In order to accommodate the market demand for office uses while still maintaining the integrity of the circulation system, the City of Irvine passed an ordinance containing the following features:

(a) The area is divided into zones, with each zone limited to a certain number of "development points" per acre. Different types of uses "use up" development points at a different rate, depending on the relative traffk-generating characteristics of the uses. This approach allows the city to regulate the traffic generating potential of a development, while giving the developer the flexibility to propose a variety of uses. This in effect is a performance standard. The upper limit on development translates into a development density of a floor area ratio (FAR) of OS-l.0 depending on the zone. An upper limit of 15 million square feet was also established on the total amount of development that could occur, as determined by the traffk analysis.

(b) To pay for the circulation improvements required to accommodate the extra growth, a development impact fee has been established, with a higher fee for high intensity developments ($5.64 per square foot). Any fees must be paid prior to occupancy of the project. Credit is given to developers for instituting transportation management programs.

- **Florida's Growth Management Legislation**

In 1985 the Florida State Legislature enacted the Omnibus Growth Management Act and created an array of instruments and mechanisms to implement a growth management process. The principal focus of the growth management process is the legislative mandate for each local government to adopt a comprehensive plan and a set of subsequent land development regulations. The Act requites greater enforcement of local plans and consideration of capital facilities and the means to pay for them. A major thrust of the new Act is for localities to project their needs for roads, water, sewer and other facilities, then ensure that the facilities are funded and constructed concurrent with the growth they serve. Each community must develop levels of service for transportation, education and other services. Once the local government plan is approved by the state and adopted by the local government, communities may not issue building permits or adopt zoning changes which would result in a decline in the level of service below the standards.

The local plans must include implementation policies and must be consistent with state and regional plans. Failure to adopt a comprehensive plan could result in the withholding of state funds, including transportation funds.

BENEFITS/COSTS: The benefits of a growth management strategy primarily rest in the costs saved from not having to build new highways. The closer one can relate development levels to the capacity of the transportation system for handling development-generated trips, the better decisions can be made on where and how to provide new highway capacity. A comprehensive growth management strategy can also be used to help a community better understand what it wants to be in the future, and the alternative strategies for getting there.

There could be some administrative costs associated with implementing a growth management strategy. Depending on the specific actions implemented, some administrative oversight and planning activity is required to assure equitable application of the growth management requirements.

IMPLEMENTATION: Experience with growth management strategies has shown that the following steps are critical to success:

1. Identify the most pressing symptoms of growth management-related problems.
2. Consider alternatives for quick responses to the pressing symptoms taking into account the community's administrative, financial, and political situation.
3. Combine these quick responses with short-term steps to address the need to plan and initiate a broad-based growth management effort.
4. Begin the long range task of comprehensive planning and on-going land use management and administration.

Some regulatory tools that are available to many communities include amendments to zoning language, modifications to zoning maps, adoption of new subdivision regulations, changing other permitting procedures (e.g., driveway permits), etc. Many of these tools can be very controversial so it is important that the general public be made aware of what is being proposed and the implication of doing nothing.

References

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2. E. Deakin. "Land Use and Transportation Planning in Response to Congestion." Paper delivered at the 68th Annual Meeting of the Transportation Research Board, Jan. 1989.
3. S. Glazer. "Gridlock in Suburbia." Congressional ***Quarterly Editorial Research*** Reports, Vol. 1, No. 21, June 1988.
4. R. Dowling. "Controlling Growth With Level of Service Policies." Paper delivered at the 68th Annual Meeting of the Transportation Research Board, Jan. 1989.

ACTION: Road Pricing

DESCRIPTION: By charging motorists a ' 'price" that represents the cost they create by using a particular road, individual drivers will react to this cost by 1) accepting it, 2) adopting another mode of transportation, 3) going another route, or 4) foregoing the trip. For example, an additional car wanting to use a congested highway adds delay to all of the users of that road. According to a road pricing strategy, this car would be charged its cost (in terms of value of time for the additional delay). The intent of road pricing then is to "price" highway facilities so that a sufficient supply of highway capacity is provided for those willing to pay this "price." Several experiments have been adopted in foreign countries where advanced equipment (automatic vehicle identification) is used to monitor the vehicle use of congested areas or facilities. In the U.S., such equipment is being applied in toll booths to speed traffic through the lines. The closest application in the U.S. would be differential tolls/fares for use of a facility or service during peak and off-peak hours.

BENEFITS/COSTS: The benefits of such a pricing strategy could be rather substantial in that congestion would be reduced or additional revenues would be collected to provide additional transportation capacity. For many years, one of the objections to such pricing was an inability to monitor vehicle use. Advances in automatic vehicle identification technology, however, have now put such monitoring within the realm of feasibility. One of the costs of a road pricing scheme would thus be the installation of monitoring devices on the road and in the vehicles, and the creation of an administrative/enforcement structure to collect the revenues.

IMPLEMENTATION: The implementation characteristics of a road pricing scheme are often quite formidable. The technology is now available to monitor the use of specific, well-defined facilities (e.g. toll facilities). However, an areawide application over all users and all facilities would be difficult. In an urban area, the effectiveness of such a scheme would depend on an areawide application to minimize diversions on "unmonitomd" roads.

Perhaps the most difficult aspect of implementing this scheme is political. Tolls are widely used and accepted throughout the country. However, most individuals would likely view an areawide road pricing scheme as another form of taxation and the general population reaction could be quite unfavorable. In today's political environment, road pricing as described above, except in specific instances (such as toll facilities) where it can be logically explained to the users, is not likely to be adopted in many communities.

References

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3. S. Morrison. "A Survey of Road Pricing." ***Transportation Research,*** vol. 20A, no. 2, 1987.

ACTION: Auto Restricted Zones

DESCRIPTION: An auto restricted zone (ARZ), in its broadest sense, refers to any land area where vehicular travel is regulated, controlled or restricted in some manner. A variety of techniques have been used to accomplish this, including physical barriers to auto access, parking controls, exclusive use lanes, and turn prohibitions. ARZ's can be implemented for many reasons, but experience has shown that the three most stated objectives are: 1) to preserve and enhance the vitality of urban centers; 2) to improve the environmental quality in urban centers, and 3) to encourage the utilization of non-auto modes.

A 1977 review of U.S. experience with ARZ's [Herald, 1977] concluded that:

1. ARZ's can be applied successfully in urban areas of different sizes.
2. Any area proposed for ARZ treatment must have a stable base of attractiveness as a minimum for renewing economic activity.
3. Completely prohibiting automobile traffic is not the only way of achieving the desired results.
4. The extent of transportation impacts is directly related to the degree of automobile restriction.
5. The most important transportation issue is maintaining accessibility.

BENEFITS/COSTS: Depending on the size and purpose of the ARZ, the impacts can vary from insignificant to substantial. Table 6.1 shows some of the impacts of selected ARZ's in the U.S. Where retail activities existed in the area, the ARZ generally seems to have had a positive effect on business. Pedestrian volumes, as expected, increased. The costs of the ARZ's also varied by type of facility.

IMPLEMENTATION: The most effective strategy is one which focuses on facilitating existing pedestrian and transit patterns, with subsequent stages dealing with latent activity and development potential. A great deal of attention must be given to the design of the ARZ, including pedestrian amenities, goods delivery, security, utility location, landscaping, lighting, and access to stores. The redesigned street system which now provides circulation to diverted traffic must also be structured in a way that is not confusing to drivers. This includes unambiguous signing, buffers between automobile and pedestrian traffic, and clear access to parking locations.

One of the most critical aspects of implementing an ARZ is working with the business community that is affected by the new auto restrictions. Businessmen are often opposed to anything that they perceive will hurt customer access, and automobile access is considered critical to retail success.

Table 6.1—Selected Auto-Restricted Zones in the United States

Site	Merchant's Attitudes: Before Construction	Merchant's Attitudes: After Construction	Retail Sales: During Construction	Retail Sales: After Construction	Pedestrian Volumes	New Construction	Cost & Financing
ALLENTOWN, PA. Hamilton Mall 1973	n a.	n a	n.a.	n.a.		+ Extensive new development and renovation downtown	Construction by City and State funds Maintenance by assessment district
ATCHISON, KANS. 1963	n a	n a	n a	+ up 25%		+ $4 million	$ 300,000 City funds
BURBANK, CA. Golden Mall 1968	− Strong opposition	+ Almost all in favor	+ Improved	+ up 22%		+ Little new construction, lowest vacancy rate since 1939	$ 973,000 Bond issue, owner and merchant assessment
DANVILLE, ILL. 1967	+ Merchants main force behind mall.	+ Almost all in favor	0 no loss	+ up 10–19%		+ Remodelling, storefront improvements, expansions	$ 112,000 City funds, owner and merchant voluntary subscription
HONOLULU, HA. Fort & Hotel St. 1969	n a	+ Almost all in favor	− down 5–10%	+ up 7–20%		+ New retail space added	$1,336,000 City funds and Special assessment
KALAMAZOO, MICH. Burdick Mall 1959	n a	n a	n a	+ up 15%	+ 40%	+ $16 million. 84% of stores remodelled	$ 120,000 City funds and Special assessment
LOUISVILLE, KY. River City Mall 1973	+ Businessmen played major role in planning.	n a	n a	+ up 15–25%		+ 2.5 million sq. ft of new construction	$1,500,000 City funds and Special assessment.
MIAMI BEACH, FL. Lincoln Rd. Mall 1960	n a	n a	n.a	+ up 10–25%	+ 50%	n.a	$ 600,000 Bond issue.
MINNEAPOLIS, MINN. Nicollet Mall 1968	+ Businessmen initiated mall proposal	+ Great support	+ gains up to 65%	+ up 14–30%		+ $250 million directly adjacent or within ½ block	$3,875,000 Federal funds, Bond issue, Assessment
OAKLAND, CA. Washington St. 1961	− Merchants opposed	− Apathetic	− some loss	+ up first few years, then level		− Area slated for renewal 3 blocks cleared, no new construction	City funds and Assessment
POMONA, CA Pomona Mall 1962	+ Merchants main force behind mall	+ Optimism waned, but returning	− down 10%	+ 16%	+ 73%	+ $7.7 million Small stores closing, dept stores expanding	$ 640,000 Assessment and Bond issue
PROVIDENCE, R.I. Westminster Mall 1965	n a	+ Many in favor	0 no loss	− 1 5% (−20% rest of city)		n.a	$ 530,000 Federal grant, City funds, Assessment
RIVERSIDE, CA. Main St. Mall 1966	+ Mostly in favor	+ Almost all in favor	− some loss	0 no losses (rest of city had losses)		+ Office and bank construction planned	$ 720,000 Assessment
SALISBURY, MD. Downtown Plaza 1968	+ Merchants main force behind mall	+ 100% happy	0 no loss	+ up every year		+ New businesses attracted	$ 150,000 City funds and Assessment
WASHINGTON, D.C. F St. Mall 1966	+ Most in favor	+ Most in favor	n a	+ 4 8% (−5 4% rest of city)	+ 23%	n a	HUD funds

Key to Symbols: + Positive − Negative
n.a.—not available

Source: William S. Herald, Auto Restricted Zones: Background and Feasibility, U.S. DOT Report DOT-TSC-1057, Washington, D.C. 1977.

A successful implementation strategy must therefore include efforts to incorporate business concerns into project planning and design.

References:

1. Herald, William S., ***Auto Restricted Zones Background and Feasibility,*** Final Report DOT-BC-1057, U.S. Department of Transportation, Washington, D.C., 1976.

ACTION: Parking Management

Parking management is a very important tool for managing transportation demand. A discussion of parking management actions is found in Chapter 3.

ACTION: Site Design to Minimize Traffic

DESCRIPTION: Major activity centers are designed to include activities/services, internal circulation systems, and linkages to the regional transit system that reduce the need to access the site by automobile. For example, an oft-cited reason for solo driving to work is the need or convenience of shopping and running errands on the way to or from work. A recent survey of office workers in suburban employment centers showed that 60 percent of all respondents made at least one stop on the way to or from the office. On-site provision of common every-day services, such as dry cleaning, video rental, pharmacy prescriptions, film development and groceries is thus a necessary precondition for significant multi-occupant trips to such sites. Day-care is usually mentioned as the most desired on-site service, but "convenience stores" and "convenience service centers" are also receiving increasing attention from corporate employers and office park managers.

BENEFITS/COSTS: Such site design practices are not that common today so there is very little experience with what impacts they will have. This is a long-run strategy, and primarily aimed at individual sites. Thus, the contribution to areawide solutions is likely to be limited.

IMPLEMENTATION: The implementation of congestion-reduction site design practices requires two things-a site plan review process which allows community officials to influence design details and/or a developer willingness/commitment to incorporate congestion-reduction design characteristics into the site. Because the effectiveness of such measures has not been established, it might be difficult to convince site developers to spend the extra money to provide these activities/services. The success of doing so thus rests with the negotiating skills and technical capability of community officials.

Reference

1. Stover, V., and F. Koepke. ***Transportation and Land Development.*** Washington, D.C.: Institute of Transportation Engineers, 1988.

ACTION: Negotiated Demand Management Agreements

DESCRIPTION: Local governments mandate private sector involvement in traffic mitigation as a condition of individual development approval. Negotiated traffic mitigation agreements have become a common practice in numerous jurisdictions, including Dallas, Fairfax County VA, Los Angeles, Montgomery County MD, Orlando, San Francisco, and Seattle. The agreements set a traffic reduction goal (often expressed in terms of a minimum level of ridesharing participation, or a stipulated reduction in the number of automobile trips), but differ in the degree of prescription concerning implementation methods. An example of a non-prescriptive approach are the trip reduction agreements negotiated by the Montgomery County (MD) Planning Board. The agreements specify the number of vehicle trips to be ultimately eliminated from a given development but leave wide latitude to the developers in deciding how those reductions are to be achieved. Other jurisdictions have adopted a more prescriptive approach. Thus, the "Development Disposition Agreements" negotiated by the Community Redevelopment Agency of Los Angeles (see below) not only set a performance requirement, but also list a number of specific actions the developers must adopt to carry out the intent of the agreement. A description of these instruments follows.

- **Trip Reduction Programs Negotiated by the Montgomery County Planning Board**

Montgomery County's Adequate Public Facilities Ordinance requires the County's Planning Board to examine each applicant's proposed subdivision to determine whether there are sufficient transportation facilities to adequately handle to additional traffic generated by the new development. If the Planning Board finds that adequate transportation facilities are not available, the Board may disapprove construction of the subdivision in question.

One way, however, for an applicant to obtain immediate approval in such circumstances is to agree to implement a "trip reduction" program. Trip reduction programs must compensate for the peak-hour trips generated by the certain stipulated measures and achieving specific trip reduction goals, which are normally set high enough so that after the new development has been occupied, the traffic situation is at least no worse than it was before. If a program does not perform as expected and no way can be found to strengthen it, then the program goes into default and the developer forfeits a substantial letter of credit or bond, the proceeds of which are used by the County to operate the program itself.

The first trip reduction program was negotiated in 1986 with the developers of Rock Spring Park, a 24-acre, 1.1 million square-foot mixed-use project in North Bethesda. As a condition of subdivision approval, the developers agreed to: (a) establish and maintain a ridesharing/transit promotion program whose ultimate goal is to eliminate 532 peak hour trips from the complex (an interim goal of fifty percent of the final trip reduction goal must be achieved before building permits are allowed to be issued for the third phase of the project), (b) establish and maintain a full time ridesharing administrator for the program: (c) monitor and report on the progress of the ridesharing program and calculate the resulting trip reductions; and (d) post an irrevocable bond or letter of credit in the amount of $772,000 which, in the event of failure to achieve the stated ridesharing goal, will be considered as liquidated damages and used by the County to finance the operation of the County's ridesharing program for the balance of the ten-year term of the agreement.

Similar trip reduction agreements have been concluded by the Planning Board with several other major commercial complexes.

- **"Development Disposition Agreements" of the Community Redevelopment Agency (CRA) of Los Angeles**

The CRA's Development Disposition Agreements (DDAs) probably contain the most elaborate set of traffic mitigation requirements on record. CRA's decision to promulgate traffic mitigation conditions stems from the City's concern about the effects of additional office development on the already badly congested downtown area. To stem the influx of yet more commuter automobiles into the crowded central business district, the CRA has begun to impose ridesharing requirements on new downtown office buildings. The DDAs stipulate that a certain percentage of office employees must arrive at the sites by other means than single occupant automobiles. In a recent case involving a new office tower, the ridesharing goal was set at 44 percent. The DDAs also commit the developers to certain specified implementing actions, such as hiring a "Commuter Transportation Coordinator," providing rideshare incentives, and monitoring employee participation in the ridesharing program. Finally, the agreements contain a long list of "recommended policies"-i.e., actions which are considered supportive of the requirement but are not obligatory. Among them are subsidized transit passes, preferential parking policies for Carpools and vanpools, and involvement of tenants in traffic mitigation programs through lease conditions.

The agreements are enforceable through a complex set of provisions that require developers to provide (or pay for) free van seats equivalent to the shortfall between the rideshare performance requirement and the actual number of rideshare participants, in the event a project fails to achieve the rideshare performance requirement.

BENEFITS/COSTS: Similar to those for trip reduction ordinances (see "Trip Reduction Ordinances" later in this chapter). However, negotiated agreements are focused on a particular site and thus do not provide areawide consistency in reducing generated trips.

IMPLEMENTATION: The basis for such agreements is often found in legislation or regulations which give community officials some leeway over development characteristics. Successful implementation of negotiated agreements depends on having technical staff capable of negotiating with developer's consultants. The level of mitigation required and the contribution of individual mitigation measures is often the point of contention in such negotiations. Communities need to have the technical capability for analyzing the impact of mitigation measures.

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4. C. Orski, "Managing Suburban Traffic Congestion: A Strategy for Suburban Mobility." *Transportation Quarterly,* Vol. 41, No. 4, Oct. 1987.

Mitigating Existing Congestion

ACTION: Ridesharing

DESCRIPTION: The term "ridesharing" came into use during the 1970s to generically denote the act of sharing vehicles for the trip to work. Ridesharing can involve "carpooling," vanpooling," and "buspooling." Ridesharing usually constitutes a key element of a demand management program.

- **Carpooling**

  Carpooling involves the use of an employee's private vehicle to carry one to five fellow employees to work, either using one car and sharing expenses, or rotating vehicle use so that no money changes hands.

- **Vanpooling**

  Vanpooling generally involves the use of an 8-15 passenger van, with driving done by one of the employees, and the fixed and operating costs at least partially paid by the other riders through monthly fares.

  There are three types of Vanpool programs: company-sponsored, third-party and owner-operated. In company-sponsored programs the company owns or leases vans and administers the program. In third-party programs, a ridesharing organization or some other agency or van leasing company offers a Vanpool service. The third party administers the Vanpool program and takes on the financial liability. Owner-operated vans are the sole responsibility of the owner/driver. Owner/operated Vanpools can be encouraged and facilitated by employers.

A combination of the third-party and the privately owned program is the Vanpool "transition" concept used by some public agencies, such as the Golden Gate Transportation District. The program uses a small vanpool fleet owned by Golden Gate to introduce commuters to vanpooling. After a trial period, commuters are encouraged to purchase or lease vans themselves. The Golden Gate vans are then turned over to a new group.

Third-party Vanpool programs have become increasingly popular across the country because they relieve the employer of the legal and financial risks involved in setting up a Vanpool program, and also provide administrative, matching and insurance services at no cost to the employer. In effect, the third-party organizations act as a consultant and a broker for employers and employees who wish to organize a Vanpool.

- Buspools

Buspools are also known as charter, club or subscription buses. Buspools are usually initiated by employers, although residential-based buspools have also been formed under the auspices of transit agencies homeowners associations and private bus companies (e.g. Chicago's Southside).

The basic element of a ridesharing program is the provision of ridematching service. This service can be provided at four levels:

1. *At the regional level*, by a regional planning agency such as a metropolitan planning organization (MPO) , a regional transit agency, or an organization specially created to promote and facilitate ridesharing within a region (e.g., RIDES in San Francisco, Commuter Computer in Los Angeles).
2. *At the sub-regional level*, by a local unit of government (municipal or county). County-level ridesharing services are sometimes decentralized to provide ridematching that is closely tailored to a local market.
3. *At the sub-regional level*, by private employers. Company-sponsored ridematching services are limited to the company's own workers and often involve a more personalized approach, combined with a heavy element of marketing and promotion. In some areas, companies utilize the matching services of local or regional ridematching agencies.
4. *At the residential* end, by private developers, condominium associations and homeowners associations. Residential-based ridesharing efforts account for only a small fraction of ridesharing programs.

BENEFITS/COSTS: Ridesharing can reduce commute costs, energy consumption per passenger, highway congestion, parking space demand, and air pollution. By encouraging employees to rideshare, the company can benefit in terms of better employee morale, reduced absenteeism and tardiness, a potentially expanded labor market, lower capital costs for employee parking and an improved public image. Ridesharing programs can also help a company retain employees when a plan relocation has to be made.

The most visible cost saving for the employer is a reduced need for parking spaces. For each vanpool formed, a company can remove at least six vehicles from its parking facility. For each three-person carp001 formed, a reduction of two spaces can be realized. Each Vanpool can save a company up to $20,000 in new parking space costs, each Carpool $7,000.

Cost savings are also a persuasive argument for selling ridesharing to commuters, especially for long distance Vanpools. With a typical Vanpool commute of 70 miles mundtrip, 13 passengers in a vanpool would each pay approximately $60 a month; driving alone in a subcompact car on that same commute would cost each person $300 a month. In one year, the Vanpool rider on the 70-mile round trip commute can count on a $2,900 savings. The following table gives other examples of the cost savings enjoyed by those who ridesharing to work.

Monthly Commute Costs

Daily Commute	Driving Alone	3-person Carpool	Vanpool (I3 riders)	Vanpool Driver
30 miles	$165	$55	$45	$0
50 miles	231	77	52	0
70 **miles**	300	100	60	0
90 miles	366	122	67	0

SOURCE: MTC commute Alternatives Manual, 1982

IMPLEMENTATION: The successful implementation of employer-based ridesharing depends greatly on the commitment of the employer toward encouraging employee ridesharing. This could mean providing a ridesharing coordinator, preferential parking for ridesharing, newsletter, subsidies, etc.

Customized commuter transit services have been introduced by some companies and corporate office parks, where large numbers of workers share a common residential origin. In such circumstances it has been found possible to structure privately-operated bus services that offer door-to-door transportation or direct connections to and from a common staging point, such as a freeway park-and-ride lot. Customized transit services work best in corporate facilities with large manufacturing or back-office operations where workers are on set shift schedules.

Surveys have shown that people bring their cars to work for multiple reasons. One oft cited reason is the need to have access to a car during the day. When probed more deeply, some respondents say they need a car in their work, others to run errands during the lunch break. Still others indicate they drive because they don't want "to get stuck" in case of a sudden emergency at home. Whatever the reason, more and more employers are discovering that provision of daytime and emergency transportation (so-called "Guaranteed Ride Home") is an important inducement to alternative transportation.

Daytime transportation services in suburban activity centers may involve: (1) local circulators connecting office buildings, hotels, retail activities and services; (2) shuttles to commuter rail stations, rapid transit lines and peripheral parking lots: (3) short-term car rental outlets that lease cars by the hour: (4) employer-furnished fleet cars for midday and emergency use; and (5) taxi vouchers for emergency trips home.

References:

1. Metropolitan Transportation Commission, Commute Alternatives, A Manual for Transportation Coordinators, 2nd ed., January 1983
2. Metropolitan Transportation Commission, Traffic Mitigation Reference Guide, December 1984; Update, February 1986
3. Federal Highway Administration, Ridesharing Implementation Guide, December 1981
4. Urban Land Institute, Sourcebook on Transportation Management (draft), November 1986
5. American Public Transit Association. Final Report of the APTA Ridesharing Task Force. Washington, D.C. : APTA.

ACTION: Alternative Work Hours

DESCRIPTION: Spreading the demand for travel over a wider band of time through "alternative work hours" programs is another demand management technique. By spreading demand, an existing bus fleet and road network can serve more commuters without additional investment in peak capacity. There are three methods of spreading commuter travel demand:

Staggered Hours. With staggered hours, different work groups are assigned to begin work at different times. Spacing arrivals at specified intervals before and after conventional work hours allows workers to travel at times when traffic moves more freely and more seats are available on transit. Staggered hours work well for assembly-line operations and back office operations where commencement and termination of work shifts can be easily controlled by the employer.

Flex-time. Flex-time is a scheduling practice that allows individual employees to choose their own schedules within company-set guidelines. Most flex-time arrangements allow employees to begin work as early 7 a.m. or as late as 9:30 a.m. and many allow workers to vary their arrival times from day to day. Flex-time works well for office workers who work independently and can exercise a certain amount of discretion over the scheduling of their work.

Compressed Work Week. Four-day work weeks allow employees to complete 40 hours of work in four lo-hour days. The system is often called 4-40. Four-forty systems have a double impact on travel to work: one day of commuting is eliminated each week; and the early arrivals and late departures built into the ten-hour days mean employees travel before and after the rush hour peaks.

BENEFITS/COSTS: The main benefit of staggered work hours is the relief of traffic congestion. By adopting earlier or later hours than nearby companies, a company allows its employees to avoid the worst periods of traffic congestion and transit crowding. Large companies may also stagger work hours to alleviate on-site crowding at plant gates and exits from office parks.

The benefits of flex-time accrue to the employee, the company and the community. The community benefits from the easing of rush-hour congestion. Flex-time also offers the scheduling flexibility needed to meet bus schedules and arrange car-pooling more conveniently. After flex-time is introduced, more employees usually begin to carp001 and use transit. In Seattle, a survey of employees placed on flex-time showed a decrease in the percent who drive alone from 24 percent to 14 percent. Among employees in San Francisco's financial district, the percent who drive to work alone fell from 3.5 percent to 1 percent after flex-time was introduced.

IMPLEMENTATION: Any city or area considering work scheduling changes should consider these key questions in evaluating factors working for and against the adoption of the changes in their area:

(1) Is there a single large employer (the federal government usually) or a strong merchants' association within a specific portion of the central business district? (favorable)

(2) Does the proposed plan concentrate on a specific work area or portion of the central business district (favorable) or does it apply instead to the who city or region? (unfavorable unless the same proportion of participants can be maintained)

(3) Is it likely that public transit will cooperate in making any routine or scheduling additions or changes necessary? (favorable-consequently the plan may work best in areas where transit is fairly solvent or is publicly controlled)

(4) Is the area an involved one which has a concentration of administrative offices (favorable) or an area of offices or stores depending heavily on consumer contact? (unfavorable)

(5) Is the area one in which most offices are to be newly opened, such that employee scheduling and arrangements are disrupted anyway? (favorable)

(6) Is the plan one which union officials will accept? (favorable-note that unions oppose longer daily hours as well as four-day work weeks in which the three days off are not consecutive)

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1. Metmpolitan Transportation Commission, Traffic Mitigation Reference Guide, December 1984.
2. David W. Jones, An Employer's Guide to Flexible Working Hours, Institute of Transportation Studies, UC/Berkeley, February 1983.
3. Cohen, Allan, and Herman Gadon. *Alternative Work Schedules: Integrating Individual and Organizational Needs.* Addison-Wesley, 1978.
4. Rainey, Glenn, and Lawrence Wolf. "Flex-Time: Short-Term Benefits, Long-Tern . . . ?" *Public Administration* Review, Jan.-Feb. 1981.

ACTION: Trip Reduction Ordinances

DESCRIPTION: A community's regulatory authority is used to limit trip generation from new developments. Ordinances appeal to local officials on several grounds: (1) they can potentially achieve more significant trip reductions because they usually cover an entire local political subdivision rather than just an individual project; (2) they spread the burden more equitably between existing and future development; and (3) they may be less vulnerable to legal challenges than conditions imposed on development approvals.

- **The City of Alexandria's Traffic Mitigation Ordinance**

In May 1987 the City of Alexandria, Virginia, enacted an ordinance "to mitigate traffic and related impacts of certain. . . land uses through the requirement that a. . . special use permit be issued for such uses containing terms and conditions which require the implementation of an appropriate transportation management plan." The application for the special use permit must provide the results of a traffic impact study showing projections of future traffic volumes and level of service for designated intersections, and must propose a traffic mitigation plan.

The permit will be approved if the city council determines that the actions proposed in the plan "will produce a significant reduction in traffic." The ordinances set forth the following criteria for evaluating the adequacy of the actions: (a) 10-30 percent of the morning peak period trips generated by the project will utilize "a mode of travel other than single occupancy vehicle (SOV)" or (b) no more than 40 percent of SOV trips generated by the project between 6 am and 10 am or between 3 pm and 7 pm will occur during the peak hour.

The traffic mitigation actions shall be "fully and continuously implemented throughout the life of the proposed project." The special use permit incorporating the traffic mitigation conditions shall run with the land and shall be binding on the developer and his successors-in-interest.

- **The Silver Spring, Maryland, Transportation Management District**

Downtown Silver Spring, a suburban center in metropolitan Washington D.C., has become the target of significant urban revitalization efforts. In order to accommodate the proposed new commercial development without running afoul of the County Annual Growth Policy (which sets development limits as a function of available transportation capacity), the County has established a special Transportation Management District.

Authority to create such districts derives from Article 25A of the Maryland Code, which gives "chartered" counties broad powers to establish "special taxing areas," exercise planning and zoning controls, and enact local ordinances "for the protection and promotion of public safety. . . health and welfare.... relating to the use of streets and highways."

The aim of the District will be to maintain traffic levels consistent with "commuting goals" specified in the County's Annual Growth Policy, which, in the case of the Silver Spring central business district, require a 25 percent transit modal split. In other words, one out of every four peak hour commuters must use transit or ridesharing. This “commuting goal” is to be reached by enlisting the business community in a concerted program of demand management. All employers of more than 2 5 workers are required to submit traffic mitigation plans and participate in an annual commuter survey. All new developments are required to enter into binding traffic mitigation agreements as a condition of subdivision approval and must meet a 30 percent transit modal split. An advisory board of local citizens and business leaders will oversee the program and evaluate the progress in attaining the commuting goals.

Significantly, the proposed legislation provides no penalties against employers who fail to meet the traffic reduction goals. However, fines will be levied for failure to comply with procedural requirements-i.e. for not making a good faith effort to carry out the intent of the legislation. Developer agreements, on the other hand, will contain binding sanctions, and will be enforced through financial security assurances and liquidated damages. And, the program may become mandatory for employers as well if the commuting goals are not met through voluntary efforts.

The most novel feature of the Silver Spring TMD legislation is its aggressive use of public incentives and parking controls to secure private sector cooperation and achieve the desired commuting goals. The package of incentives includes park-and-shuttle service into the CBD, discounted transit and commuter rail passes, and discounts for carpools and vanpools in the County-operated parking facilities. Employers who exceed the modal split goal will receive additional incentives.

Of even greater significance is the County’s ability to control the supply of downtown parking and its avowed determination to constrain the supply of commuter parking within the Transportation Management District, while at the same time vigorously enforcing commuter parking bans in the surrounding residential neighborhoods.

The Silver Spring Transportation Management District represents a bold and far-reaching exercise of local police powers to regulate automobile use and control traffic congestion. Its underpinnings is the County’s long standing bipartisan acceptance of the principle of managed growth, as reflected in its Annual Growth Policy and the Adequate Public Facilities Ordinance.

BENEFITS/COST: Trip reduction ordinances are a relatively new phenomenon and thus there is limited experience in determining their effectiveness. Results from some examples, however, suggest that there are benefits; ridesharing and transit trips have slightly increased and some auto trips have been shifted out of the peak period. If monitored and enforced, trip reduction ordinances could have an impact on alleviating future congestion in a community.

In those instances where there are "spillover" effects from one community to another, there is a need to provide an areawide trip reductions program. Otherwise, one community’s efforts will be overwhelmed by another’s inability to control traffic growth.

IMPLEMENTATION: An examination of existing traffic mitigation ordinances reveals a large degree of commonality in the way local jurisdictions are approaching the subject of regulating automobile use.

Extent of Coverage. Most of the ordinances apply both to new and existing development and explicitly cover employers. However, some ordinances (Alexandria, Hartford, Los Angeles/Coastal Corridor) apply only to new development, and other ordinances (Contra Costa County, Pleasanton, Seattle) impose more stringent requirements on major employers than on small employers.

There is an almost universal exemption for residential uses; enforcement of traffic mitigation requirements against residents is felt to be too onerous and virtually unenforceable.

Where the ordinance applies to developers or property owners, it usually remains silent as to tenants. As a matter of practice, however, developers and property managers often incorporate the ordinance conditions in their leases and CC&Rs.

Flexibility of Means. Some ordinances (Placer County, Sacramento, Seattle, Bellevue, Hartford) require implementation of specific TSM measures. Most ordinances, however, only prescribe traffic mitigation goals, without specifying how these goals are to be met. The targets are typically expressed in terms of: (1) percentage reduction in peak-hour vehicle trips; (2) percentage of "driver-only" vehicles: (3) average vehicle ridership in the peak hour; or (4) "acceptable" traffic conditions at designated survey points ("Level-of-Service Ordinances").

Enforcement and Sanctions. Should failure to reach a prescribed goal be penalized? Or should only "good faith efforts" be required? The majority of the ordinances provide penalties for failure to comply with procedural requirements, such as the submission of a TSM plan, or a survey report. A few go somewhat further and penalize failure to implement an approved TSM plan (Contra Costa County, Pleasanton, Santa Clara County). However, none of the ordinances impose penalties for non-attainment of the trip reduction goals. Indeed some ordinances (LA, Phoenix, Tucson) explicitly state: "Having made a reasonable effort to duly comply with the provisions of this Section, failure. . . to meet the applicable goals shall not be considered a violation of this Section."

Some ordinances require the traffic mitigation conditions applicable to new development be recorded as covenants running with the land. Failure to carry out the traffic mitigation programs is thus enforceable not only against the initial developer but also against all subsequent owners of the property.

Oversight/Monitoring/Citizen Involvement. Virtually every ordinance provides for some kind of a collaborative public/private oversight, but the ordinances vary in the degree of power and responsibility accorded to the oversight bodies. Most are purely advisory (Contra Costa County, Concord, Los Angeles), but at least in one case (Pleasanton) the "TSM Task Force" also has the power to approve or reject TSM plans, refer violators to the City

Council, and recommend changes to the ordinances.

The burden of monitoring is almost invariably placed on the private parties who are required to submit an annual progress report. Many jurisdictions also require submission of annual surveys of employee commute patterns.

References

1. Flynn, C., and L. Glazer. "Ten Cities' Approach to Transportation Demand Management." Paper presented at the 68th Annual Meeting of the Transportation Research Board, Jan. 1989.
2. Colorado/Wyoming Section of ITE: "Survey of Current Practice for Identifying and Mitigating Traffic Impacts." ***ITE Journal*** 57, 5 (May 1987): 38-44.

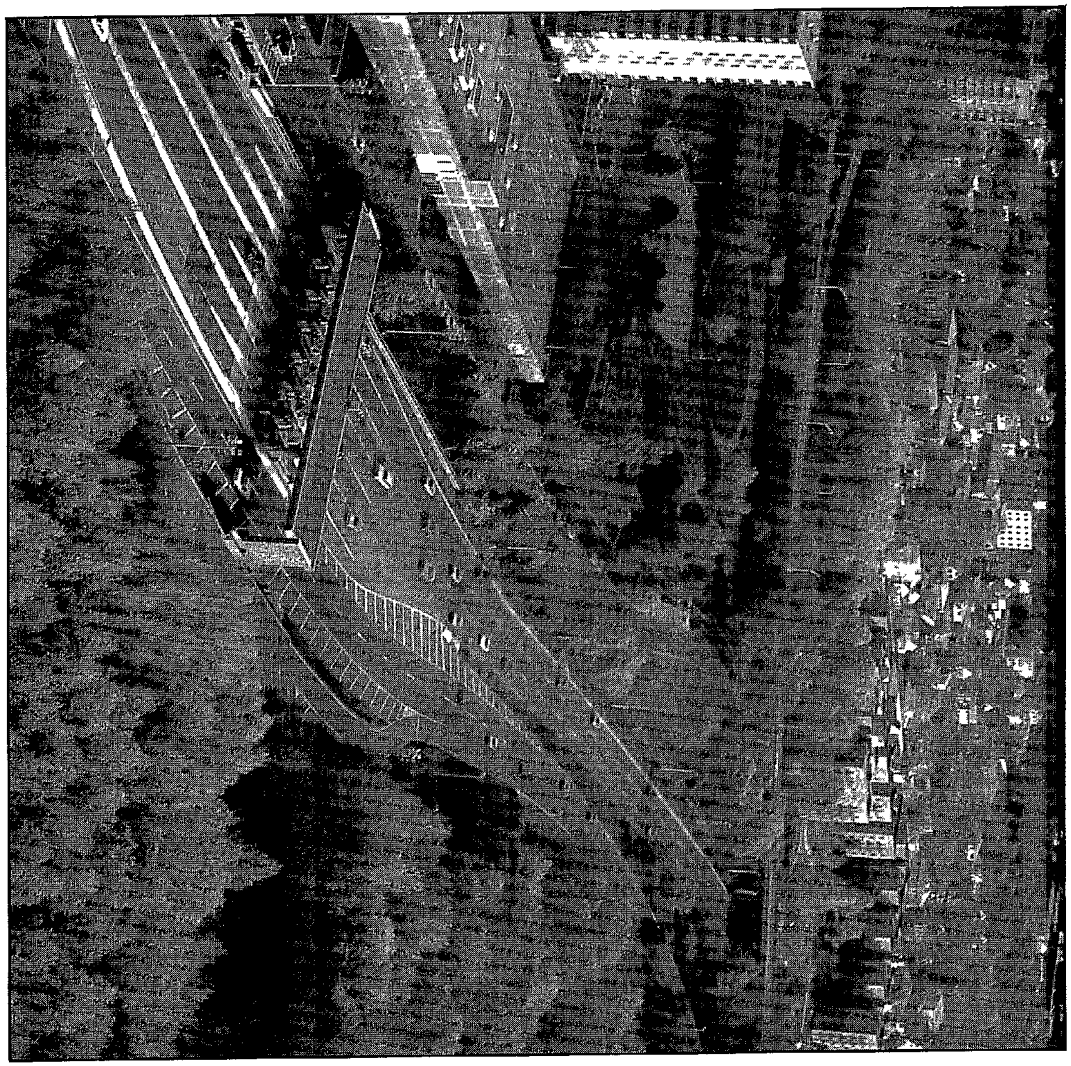

Photo courtesy of Port Authority of New York and New Jersey

7 Funding and Institutional Measures

More than any other factors in implementation, funding and institutional capability are critical to project or program success. Without adequate capital and maintenance funding, the ability of transportation officials to preserve and enhance the transportation system will be severely constrained. In this sense then, funding and institutional measures are not congestion reduction techniques per se, but are necessary prerequisites for any improvements to be made on the transportation system.

Funding

ACTION: Fuel Taxes

DESCRIPTION: The federal government, all 50 states, the District of Columbia and several metropolitan areas currently levy taxes on gasoline and other motor fuels. The federal government spends all funds generated by such taxes for transportation purposes as do the preponderance of the states and localities. As of January 1989, state taxes ranged from 7.5 cents per gallon in Georgia to 20.9 cents per gallon in Wisconsin. The federal gas tax has been at 9 cents since 1983.

BENEFITS/COSTS: Fuel taxes are an effective means of generating revenue for transportation improvements. The reliability of the revenue stream makes them attractive as a basis for issuing bonds which provide “up front” financing for construction projects. Their attractiveness as a means of raising revenue lies in the direct relationship between those who pay and those who benefit. That is, the greater the use of the highway system, the more contribution to its upkeep and expansion.

In many debates on raising the gas tax, opponents often claim that a gas tax increase will have a serious economic impact on a region’s or state’s economy. This impact is described in terms of jobs lost and reduced economic competitiveness. These claims are usually based on general supply demand relationships which imply a cause and effect linkage between gas price as one factor, influencing economic decisions, and the economic health of a region. There is little or no information on this linkage as it has actually occurred following the increase in gas taxes.

IMPLEMENTATION: Legislation and/or a referendum are usually required to implement a gas tax. Because of this, the politics surrounding a proposed gas tax increase can be quite volatile. Experience from successful efforts in the U. S. suggests that the following steps are necessary to increase a gas tax:

1. Clearly define in understandable terms the needs that will be addressed by increased funding.
2. Develop a comprehensive package of transportation improvements so that voters can see what they will get for increased taxes.
3. Create a consensus among transportation agencies that an increase is necessary.
4. Have advanced negotiations with key actors in the policy process (e. g., governor, legislative leadership, business community, transportation organizations, etc.).
5. Provide opportunities for public input and build support among public groups.
6. Work with the media to get favorable coverage.
7. Establish a credible focal point of overall leadership.

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1. Public Technology, Inc., *Inflation-Responsive Financing For Streets and Highways,* Washington D. C., June 1982.
2. Gary R. Allen, "Highway User Fees: Are These Old Taxes Still Good Taxes?", in *Understanding The Highway Finance Evolution/Revolution,* American Association of State Highway and Transportation Officials, Washington D. C., January, 1987.
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4. Federal Highway Administration. *Road User and Property Taxes, 1987.* Report HPM-10/7-87. Washington, D.C.: FHWA, 1987.

ACTION: General Revenues

DESCRIPTION: Some portion of the sources of funds used to finance government, (e. g., property, sales and/or income taxes, lotteries, lease income, and commuter/business/professional taxes) is used to support transportation investment. These funds have been used by local governments more often in the past several years to compensate for a reduction in funds from other sources.

BENEFITS/COSTS: The benefit of using general revenue funds for transportation purposes lies mainly in the general public acceptance of taxation as a mechanism of supporting government (although the amount of taxation can be debated endlessly). Also, some forms of general revenue taxes (e.g., sales tax) can provide substantial levels of funds to transportation if dedicated for that purpose. The major disadvantage of such funds is that they compete with other community needs for yearly budget allocation. Thus, a long-term transportation program should not be based on the allocation of general revenues unless the taxing mechanism (e. g., sales tax) is devoted strictly for transportation purposes.

IMPLEMENTATION: The use of general revenue sources for transportation funding will be subject to the politics surrounding budget allocations. Thus, the use of these funds would be successful only if proponents are able to convince officials that transportation activities warrant the use of such funds. Where special taxes are raised specifically for transportation purposes (e. g., a dedicated sales tax), the characteristics of successful implementation are the same as those described earlier in the section on fuel taxes.

References:

1. Harold A. Hovey, ' 'Financing Highways With General Revenue Sources: The Role of Nonuser Fees in Highway Finance,' ' in AASHTO, *Understanding the Highway Finance Evolution/Revolution,* January 1987.
2. Ken Anderson, "Summaries of Urban Transportation Financial Planning Studies,' ' Federal Highway Administration, Washington D.C., July, 1982.
3. U. S. DOT, "Financing Transit: Alternatives for Local Government," Washington D. C., July 1979.

ACTION: Toll Roads

DESCRIPTION: Charging tolls for the use of a road has been a time-honored means of paying for the construction and operations of a highway facility. Today, there are 28 states operating 36 toll road systems in the U. S. However, many states are currently developing plans for new toll facilities. The federal highway program for years prohibited the use of tolls on federally-aided projects. However, in 1987, Congress eased this restriction and allowed eight states on a trial basis to build toll facilities using federal funds.

Toll roads can be financed in several ways-general obligation bonds, revenue bonds, revenue bonds supplemented by income other than that paid by users, private financing, and combinations of the above. The collected tolls are then used to pay off the principal and interest of these bonds.

BENEFITS/COSTS: There are several benefits to toll financing. First, they form the most direct user charge for providing revenues based on the costs of travel. Second, toll projects can be implemented more quickly than other projects because the capital funding is available upfront and because toll roads often do not have to comply with federal regulations. Third, adequate funds (as reflected in the toll rate) are provided for maintenance and operation. Fourth, the increased attention paid by toll authorities to the highway facility often provides an increased level of service when compared to similar non-toll facilities.

The disadvantages of toll roads included: paying interest on borrowed funds, costs of toll collection, delay and environmental impacts at toll booths, limited access and egress to the facility, and the added costs of land and structures to provide toll collection facilities. It should be noted that new technology relating to automatic vehicle monitoring can reduce the delays and impacts at toll booths.

IMPLEMENTATION: The use of tolls requires legislation or some authorization to permit their collection. Similar to gas tax increases, toll roads can meet political opposition. The major issue is double-taxation, the payment of a toll on top of federal and state gas taxes which are collected to build and maintain a highway system. Opposition to tolls thus comes mainly from those groups which represent road users such as automobile and truck associations. Public attitudes have generally been favorable toward toll roads, mainly because those who benefit from the improvement are also paying for it. However, successful implementation still requires many of the characteristics described in the section on fuel taxes.

Because toll road finance is heavily based on the issuance of bonds, legal and finance counsel is essential for those agencies considering toll roads. In general, the technical evaluation capability is much more rigorous for toll roads than that for similar non-toll roads.

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4. U.S. General Accounting Office. *HighwayFunding Use of Toll Revenues in Financing Highway* Projects. Washington, D.C.: GAO, April 1987.
5. Congressional Budget *Office. Toll Financing of U. S. Highways.* Washington, D.C. : U.S. Congress, 1985.

ACTION: Bonding

DESCRIPTION: To provide the necessary up-front capital for transportation projects, communities can issue bonds backed by a variety of revenue sources, including anticipated governmental grants, gasoline tax revenues, tolls, special assessments, etc. These bonds reflect the current market conditions for long-term debt and are also affected by the financial health of the issuing entity.

BENEFITS/COSTS: Similar to the discussion on toll roads, bonding provides a lot of advantages and disadvantages. By issuing bonds, the up-front capital funds are available to build more projects in a much faster timeframe than having to wait for tax receipts to pay the total cost of a project. Thus, community officials are able to take advantage of economic development of other opportunities which require transportation investment. Of course, the issuance of bonds also means you are paying interest costs on the money being used and volatility of the market can determine how good of a deal one can get.

IMPLEMENTATION: Because of the complexity involved with bond sales, a financial advisor is absolutely critical to the decision-making process. This advisor can recommend courses of action regarding short-term vs. long-term market bonds, competitive vs. negotiated sales, revenue vs. general obligation bonds, etc. In particular, the federal laws concerning the tax-exempt nature of public bonds for infrastructure improvements constantly change. The advisor can provide the current status of how federal law treats the issuance of bonds.

References:

1. Thomas W. Bradshaw, Jr., "Debt Financing", in American Association of State Highway and Transportation Officials *Understanding the Highway Finance Evolution/Revolution,* Washington D. C. , January, 1987.

ACTION: Public/Private Partnerships

DESCRIPTION: Private sector contributions are made to augment public sector support of a specific project or a program of projects. As noted in a congestion reduction guide produced for community officials in Boston, these partnerships can take many forms [Ref. l] : The types of public/private partnerships include:

Assessment Districts-a special tax levy on all property owners in a district (or on a street frontage) for an improvement which benefits primarily those specific owners, and which is approved by a majority of the property owners. Usually a district is supported by a municipality which issues revenue bonds and assesses property owners to repay the bonds.

Special Districts-an assessment district with a governing body separate from the local government. Special districts have authority to tax, issue bonds, and provide services within a specified area (e. g., the MDC) . Special districts may be dependent or independent of the state, county or local governments through which they are established.

***Tax Increment Financing*-increases** of tax revenues that are realized as a result of new development in a specified area are earmarked by financing public improvements in that area. A district is defined with a base line of existing development; improvements are paid with public funds or bonds, then repaid from increasing tax revenue from the new development.

Development Agreements-private/public agreement on specific development based on private agreement to pay for itemized elements of traffic improvements, in return for a public commitment to and assistance in removing as many impediments and delays in administrative actions as possible.

Development or Impact Fees-established to compensate the community for extra costs for public facilities that the development will cause. Paid at the time of the building permit, the fees are placed in a fund designated for construction of certain facilities.

Infrastructure Bank-a pool of federal grants, proceeds from state bond issues, state appropriations and perhaps some private capital to form revolving loan accounts as seed money for traffic and road improvements. Communities would borrow funds at no interest and repay them from user charges or other revenue sources.

EXAMPLES

Development Fees-Ft . Collins, Colorado, requires developers to provide all streets internal to the owner's project, and in addition pay a street oversizing fee for collector and arterial streets, set to recover the cost above that of a local street, and set currently at $215 per residential unit, $3,500 per gross acre for commercial development, and $500 per acre for industrial development (set low to encourage economic development).

Impact Fees-Broward County, Florida, imposes road impact fees which have survived court tests but which must be earmarked for facility expansion, preceded by planning, reasonably related to services received, and representative of a fair share of service costs. A computer model is used to determine what traffic will be generated by the proposed development. If the development will significantly increase traffic over existing capacity, the developer is required to pay a proportionate share of the costs required to increase the capacity of the road. (The developer is not required to pay for existing deficiencies in the road.) A developer may construct certain roadways and have them credited against the impact fee.

Impact Fees-Fresno, California, uses differential fees based on zones within the city. Fees for improvements in roads are different for each of the zones. Fresno uses a schedule for fees for each installation of a traffic signal as well, based on the zone in which the signal is installed.

Impact Fees-Boulder, Colorado, has a standard fee (e. g., per unit for new residential units), which is placed in an escrow account for each roadway.

***Development Agreements*-**In Broward County, Florida, all impact fee arrangements are negotiated and formally defined in development agreements between the developer and the county.

Tax Increment Financing (TIF)-Prince Georges County, Maryland, working within an overall limit on general property tax revenues, established a private/public task force, which adopted TIF because the state had stipulated that funds raised through TIFs were not subject to county tax limitations. The first district was established to finance a parking garage for an AMTRAK station. The county now has 3.2% of its land in TIF districts; state law limits the total percentage of county land in TIFs to 10%, and the total amount of county debt service from TIF districts to 15%.

Special Districts-Portland, Oregon, uses Local Improvement Districts (LIDS) which are authorized by state statute (but not controlled by the state) to finance road and other improvements. A developer can initiate a LID, but 50% of the voters in the proposed district and the city or county must approve it. The LID then issues tax-exempt general obligation bonds, which are backed by the faith and credit of the city or county, and are also supported by a lien on the properties to be benefitted by the bond revenues.

"Road Clubs" and Development Agreements-Montgomery County, Maryland, furnishes cash to finance required road improvements, and is then reimbursed either in cash per lot, payable upon conveyance of title to buyers of new houses, or by a deferred payment plan, which places road club charges on homeowners' tax bills to be amortized over 5 or 10 years. Developers may choose the method of repayment to the county. Montgomery County requires that its "road clubs" be included in formal documents called public works agreements, which identify the parties and set forth the responsibilities of the county and the developers.

BENEFITS/COSTS: Public/private partnerships provide additional funds beyond those that would have been available. This means that more projects can be undertaken in a given jurisdiction. However, this additional funding often does not come without some limitations. Court cases have concluded that such funding must be tied to projects directly related to those contributing the funds. So, the impact of increased funding is local. Also, private sector contributions are made with expectations that projects will be implemented quickly. Such quick timeframes can stretch the planning and engineering resources of the government agency. Finally, possible equity implications arise when public funding is assigned to projects to take advantage of private resources, thus causing more "needy" projects to go unfunded.

IMPLEMENTATION: Several of the public/private funding concepts discussed above require some form of legal authorization. For example, in many areas, the use of impact fees requires state legislative approval. One of the key questions in using these techniques is how much will the developer/private sector group be asked to pay? On what basis is this determined? A strong technical capability and legal counsel are critical for successful conclusions to public/private sector partnerships. Importantly, revenues from the private sector are not reliable, predictable, or stable sources of funding. Thus, a regional transportation program should not have as its foundation an assumed substantial contribution from the private sector.

References:

1. Metropolitan Area Planning Council, *Private/Public Strategies and Techniques For Reducing Traffic*, Boston, Ma., 1987.
2. C. Michael Walton, et al., ' 'Private Participation in Financing Highway Projects and Providing Property for Highway Improvements,' ' in AASHTO, *Understanding the Highway Finance Evolution/Revolution*, January, 1987.
3. C. Kenneth *Orski, Toward a Policy for Suburban Mobility*, Institute of Transportation Engineers, Washington D.C. ,1986.
4. Rice Center, *Alternative Financing for Urban Transportation: State of the Art*, U.S. Department of Transportation, Washington D.C., 1983.
5. Douglas Porter and Richard Peiser, *Financing Infrastructure to Support Community Growth*, Urban Land Institute, Washington D.C., 1984.
6. G.T. Johnson and L . A. Hoel. *An Invento y of Innovative Financing Techniques for Transportation*. Report DOT-l-86-08. Washington, D.C. : Federal Highway Administration, April 1985.
7. J. Wegner. "Public and Private Partnerships for Financing Highway Improvements." NCHRP Research Results Digest 161 (May 1987).
8. L. Meisner. *Use of Private Funds for Highway Improvements*. Report FHWA/P L/83/017. Washington, D.C. : Federal Highway Administration, January 1984.
9. J. Kirlin and A. Kirlin. *Public Choices-Private Resources*. Sacramento, CA: California Tax Foundation, July 1982.

Funding Summary

A recent report for Pennsylvania's State Transportation Advisory Committee provides a useful evaluation of the benefits and shortcomings of specific funding actions [Ref. 1]. This evaluation is presented in Table 7-l as a representation of the latest thinking on the merits of specific funding strategies.

Reference

1. J. Mason et al. ' 'Traffic Management .' ' Report prepared for the State Transportation Advisory committee, Pennsylvania Transportation Institute, April 1989.

Table 7-1-Evaluation of Alternative Financing Techniques

USER FEES

Alternative Finance Techniques	Description	Benefits*	Shortcomings*
Vehicle Registration Fees	A variety of fees and taxes imposed by most states on vehicle owners as part of the vehicle registration process. Can include a graduated tax on vehicle weight or miles traveled. Usually considered a charge for access to system and not based on use of system. Provides stable source of revenue.	1, 12	5, 10, ll
Fuel Taxes	Levied by all states on fuel sales. Some local governments are authorized to impose motor fuel taxes and share in state fuel tax revenues. Are easily administered and produce substantial revenues.	2, 3, 18	9, 15
Parking Taxes, Fees, Fines	Imposed by local governments on vehicle drivers or facility operators. Can yield significant revenue in large urban areas but may have adverse impact on local businesses.	4,21	1,2, 5, 18
Tolls	Fees charged to users of a facility. Generally based on size, weight, number of axles, and distance traveled. Can produce high amounts of revenue and are particularly useful where revenue lags behind increased traffic demand.	3,11, 12, 14, 17, 18	5
Transit Fares	Involves patronage fares, passes, and surcharges for peak-hour use. A combination of several alternatives may be necessary to maximize return.	7, 18	5
Utility Fees	Transportation tax added to water and sewer fees based on consumption. Gould include street utility fees.	2	2

SOURCE: J. Mason et al. "Traffic Management." Report prepared for State Transportation Advisory Committee, Pennsylvania Transportation Institute, April 1989.

* See list of benefits and shortcomings on pages X39-140.

Table 7-1, continued

NON-USER FEES

Alternative Finance Techniques	Description	Benefits	Shortcomings
Property Taxes	Levied on both real and personal property. May be imposed by states, local governments, or transportation authorities, although some states have rate limitations. Revenues are inflation sensitive.	5, 1	23
Income or Payroll Taxes	Includes employer payroll taxes and employee income taxes. Can produce substantial revenue due to large base; however, few local governments are authorized to use income taxes for transportation.	3	2, 15
Sales Taxes	Imposed on general merchandise, specific services, and luxury items by most states and many local governments. Some portions may be diverted or dedicated for transportation. Easily administered and responsive to inflation.	1,2,5	22
Severance Taxes	Levied on removal of minerals and natural products from land or water. Can be imposed on resource extracting industries.	30	12

SPECIAL BENEFIT FEES

Alternative Finance Techniques	Description	Benefits	Shortcomings
Tax Increment Financing	Earmarked revenues from taxes on personal and real property based on increases above a fixed base attributable to transportation improvement. Must be authorized by the state and can be used only by jurisdictions with ad valor-em taxing authority. Can be used to secure bonds.	6,7	4, 15, 16
Special Assessments	Charges to the owner of a property that benefits from an improved transportation facility. Can be based on frontage, area, value, or a combination of factors. Can be used to support bond issues, although special legislation is usually required.	16	7, 14
Traffic Impact Fees	Imposed on private developers to mitigate impacts of the development on local service. Can be in the form of tax on square footage, sponsorship of a transportation program, or improvements to adjoining facilities. Can be used as a condition for obtaining site plan approval or building permit.	6,7, 8,9	2, 4, 6, 13, 15
Service Charges	Charges on properties for direct access to a transportation facility. May be assessed as a lump sum contribution to a capital item or an annual fee to cover operating costs.	26	15

Table 7-1, continued

PRIVATE FINANCING

Alternative Finance Techniques	Description	Benefits	Shortcomings
Developer Financing	Payment of capital transportation improvement costs by private developers in return for dedicated land, construction of specific facilities, traffic control measures, changes in existing zoning and building regulations, or subsidized facilities. May be voluntary or required by law. May result in reduction of public expenditures but can be inequitable to developers.	13, 15	2
Negotiated Investments	Contributions by private developers to the cost of public transportation improvements in return for changes in existing zoning and building regulations. Revenue potential opportunities may be limited by growth, construction rate, mobility requirements, and location desirability.	15	2, 13
Private Ownerships	Includes sharing ownership costs between transportation agencies and private entrepreneurs, employer subsidies for transportation, or development of a private consortium with authority to finance, construct, and charge fees to provide transportation. Eligible for specific depreciation and investment tax credit.	20	
Private Donation	Land or capital contributions by businesses and private citizens for improvements that have strong private interest. Donors benefit from tax deductions and access.	19,20	17

DEBT FINANCING

Alternative Finance Techniques	Description	Benefits	Shortcomings
Bonds	Appropriate for high front-end capital expense where a tax or fee can be pledged for debt service. Good source for obtaining the large amounts of revenue quickly, although local government's authority is usually regulated by the state.	10, 25	8, 26
Zero Coupon Bonds	Issued by public agencies at price below face value and at a deferred unspecified interest rate. Discounting maturity value provides competitive, tax-exempt yield.	25	26,27
Interest Arbitrage	Investment of borrowed funds at a higher interest rate than is being paid. Can generate significant amounts of revenue, although public agencies face severe penalties for use other than to reinvest debt service reserve funds or to temporarily reinvest unspent bond proceeds.	3	25

Table 7-1, continued

DEBT FINANCING, continued

Alternative Finance Techniques	Description	Benefits	Shortcomings
Vendor Financing	Loan provided by manufacturer for value of equipment. Often used to gain competitive bidding advantage. Does not generally require specific revenue pledge although local agencies need authority to issue.	29	28
Private Leasing	Ownership of equipment or building by a private firm that then secures a bond and leases equipment or building to agency. Lease agreement is structured so that bond proceeds pay for most of the purchase price. Private firm benefits from accelerated depreciation allowances.	24,27, 28	27

PRIVATE PROPERTY UTILIZATION

Alternative Finance Techniques	Description	Benefits	Shortcomings
Leasing or Selling Rights	Involves the sale or lease of undeveloped land, subsurface rights, or air rights surrounding a public facility. Can generate site-specific revenue and can provide a steady, long-term cash flow.	22,24	15, 27
Leasing/ Selling Existing Facilities	Can be potential revenue source, although it may require capital outlays and sophisticated real estate and development skills. Amount of revenue is affected by availability and condition of facilities, characteristics of local real estate market. May require approval if facilities are funded by federal or state sources.	23,24	20, 21, 27

SPECIAL REVENUES

Alternative Finance Techniques	Description	Benefits	Shortcomings
Advertising Fees	Includes charging fees or taxes on billboard advertising and renting space on public facilities such as parking meters, bus shelters, vehicles, and terminals. Local government may require authority to monitor advertisements.	1, 2	19
Lottery	**Allowed** by several states although very few allocate revenue to transportation. Can result in substantial revenue although state legislation is required and operation involves close control and management.	3	3, 15, 24

Table 7-1, continued

BENEFITS

1. Stable source of revenue for public agency.
2. Easy for a public agency to administer.
3. Provides substantial revenues for a public agency.
4. Can yield significant revenues in large urban areas.
5. Revenues are inflation sensitive.
6. Taxes are based on benefits received by an owner, attributable to transportation improvements.
7. Can be used to secure bonds.
8. Mitigates impacts of specific developments on local service.
9. Can be used by a public agency as a condition for obtaining a site plan or building permit.
10. Good source of obtaining large amounts of revenue which can be obtained quickly.
11. Can be structured to encourage the use of high-occupancy vehicles.
12. Can be graduated according to the size or weight of the vehicle.
13. Developer is directly responsible for assisting in providing roadway improvements for at least part of the traffic from the development.
14. Improvements can be built quickly by a private developer.
15. Developer may have some voice concerning the improvements that are selected.
16. Costs are shifted to a group of property owners in return for special benefit that accrues to their property as a result of nearby, publicly constructed physical improvements. Cost may be shifted only to the extent of benefits received.
17. Enable a government to raise more funding for road construction than would be possible through ordinary public financing.
18. Those who use the roads or services pay for their upkeep.
19. Provides a means to complete infrastructure improvements more quickly.
20. Eligible for specific depreciation, investment tax credit, or tax deductions.
21. Can alter travel behavior.
22. Can benefit both employers and employees by providing prime location real estate to developers, office and retail space to employers, and transportation facilities to workers.
23. Governmental agency realizes a cost savings since it does not have to buy land or condemn land for transportation purposes.
24. Offers the lessor a number of options for earning tax-exempt interest, plus claiming depreciation and tax investment credits.
25. IRS considers the income to be tax-exempt for bonds issued by public entities.
26. Developer is responsible for the cost of obtaining access to the system.
27. Effective way for government to acquire assets for the least amount of up-front capital investment.
28. May reduce maintenance and administrative problems.
29. Provides flexibility in negotiating since one bidder might offer a lower price, but no financing, versus another, who could provide delivery at a reasonable price and extremely attractive financing.
30. Taxes are generally used to maintain roads used in extracting and hauling the taxed products.

Table 7-1, continued

SHORTCOMINGS

1. May have adverse impacts on local businesses.
2. Potential for economic inequality.
3. Involves close control and management.
4. Difficult to administer.
5. Collection of revenue can be labor intensive or costly.
6. Monies paid by the developer might not be used for roadway improvements near the development.
7. Statutes may limit using this device; for example, road construction may be authorized, but widening or repair and repaving may not.
8. Creates a long-term liability for the agency.
9. When not associated with inflation, the revenue can fail to keep pace with repair costs.
10. Fees do not generate revenues that are proportional to highway use unless the weight of the vehicle and the mileage driven are taken into consideration.
11. Certain "flat taxes," taxes not related to the amount of road useincurred by a motor carrier, have been found unconstitutional-for example, Pennsylvania's truck axle tax and decal fee.
12. Revenue is unpredictable.
13. Legal issues can arise in regard to the extent which a governmental body can attach conditions to zoning approvals.
14. State enabling legislation is required for the creation of Special Benefit Assessment Districts. Property owners frequently challenge the establishment of special benefits assessment districts in court.
15. Requires enabling legislation.
16. Difficult to separate transportation improvement induced benefits from other economic forces at work. Other tax jurisdictions, such as school districts or hospital districts that will be deprived of additional income, resist the creation of tax increment districts.
17. Transit agency must possess the legal power to accept donations.
18. Can discourage downtown shopping and job seeking and thus, in an overall sense, be counterproductive.
19. Kiosk advertising can hinder security by shielding areas from the view of security cameras and guards. Vandalism is a major problem.
20. Requires close interaction, persuasive powers, and political sensitivity with all parties involved.
21. Governmental agencies need special authority.
22. Sales tax tends to be regressive and the services taxes finance do not generally benefit those who pay the taxes.
23. Property tax is one of the most unpopular taxes. It has been the focus of voter resistance in the recent past. Since it is a general tax, property tax payers do not necessarily receive equal public services for equal contribution.
24. Potential for strong opposition from religious groups and from those who feel it will attract organized crime or hurt the poor.
25. Must follow strict, narrowly defined IRS rules. The change in tax law will likely complicate use of this finance technique.
26. Bond issue often involves voter referendums or special authorization.
27. Tax laws were revised several times in the previous years.
28. Requires legislation; several debates have been held in Congress on the technique.

Institutional Measures

ACTION: Transportation Management Associations (TMA'S)

DESCRIPTION: Transportation Management Associations (TMA's) are partnerships between business and local government designed to help solve local transportation problems associated with rapid suburban growth. TMA's give the business community a voice in local transportation decision-making, build local constituency for better transportation, and serve as a forum for public/private consultations on issues of transportation planning, financing, and implementation. They have become an important instrument in the fight against traffic congestion, and in increasing commuting options to suburban employment centers that are poorly served by public transportation.

TMA's offer a forum for public/private consultations on such varied issues as highway funding priorities, restructuring of public transit routes, improving transit service, minimizing disruption caused by road reconstruction, and mitigating traffic congestion. Some TMA's have been instrumental in launching innovative programs to help entry-level workers gain access to suburban jobs.

Table 7-2 shows the type of activities that could be found in a TMA.

BENEFITS/COSTS: TMA's are a relatively new phenomenon to transportation so there is no comprehensive data on their impacts. Preliminary experience has shown that they do serve as a useful mechanism for focusing the energies of the public and private sectors on critical transportation problems. In many cases, they have successfully promoted government/employer contributions to transportation improvements.

IMPLEMENTATION: The initiative to form a TMA may be sparked by a variety of motives and circumstances. In some cases, the catalyst for the TMA has been local employers and property owners who are concerned that traffic congestion could adversely affect the productivity of their operations and stifle the future economic prospects of the area. In other cases, the need for a TMA has arisen out of local ordinances that set traffic mitigation requirements on new development and obliged developers to come up with trip reduction strategies as a condition of going forward with their projects. TMA's enable their members to consolidate their efforts, pool their resources, and reduce the cost of compliance with local requirements through shared services and joint programs. In yet other cases, TMA's have been the outcome of decisions by developers, employers, property managers, and local governments to establish a vehicle for addressing local transportation problems on a cooperative basis and overcoming jurisdictional barriers that often stand in the way of areawide coordination.

Table 7-2 Typical TMA Activities

- Offer a forum for public/private consultation on:
  - Highway funding priorities
  - Minimizing disruption from road repairs
  - Transit service improvements
  - Traffic engineering improvements (placement of new signals, changes in traffic flow, etc.)
- Represent and advocate the needs and interests of TMA members before public agencies, legislative bodies, and in the transportation planning process
  - Monitor traffic conditions, and recommend appropriate "quick fix" road improvements
  - Conduct employee travel surveys, assess commuter travel needs, and recommend appropriate changes in transit muting and level of service.
  - Monitor development and employment trends, and assess their impact on future road and transit needs
  - Advise on alignment and location on new transportation facilities
- Build local constituency for better transportation and raise funds for local transportation improvements
- Promote and coordinate demand management actions designed to reduce peak hour demand on transportation facilities, and help TMA members comply with local traffic mitigation requirements (trip reduction ordinances, conditions of development permits, proffers, etc.)
  - Ridesharing
  - Variable Work Hours to spread peak hour traffic
  - Parking management
  - Transit marketing and promotion
- Facilitate commuting and provide internal circulation within the area through:
  - Daytime circulators
  - Subscription vans/buses
  - Short-term car rentals
  - Shuttles to commuter rail stations and fringe parking lots
  - Emergency transportation for employees without cars
  - "Reverse commute" services for service employees
- Provide specialized membership services to TMA members
  - Conduct employee "travel audits" -Provide relocation assistance to newcomers
  - Train in-house transportation coordinators
  - Manage shared tenant services, such as daycare centers, security, sanitation, landscaping, etc.

Experience from other jurisdictions suggests that there are several conditions that favor the establishment of successful TMA's:

- There must be a sense of a present or impending transportation problem (usually traffic congestion, although lack of commute alternatives can also be viewed as a problem);
- There must be strong corporate leadership that has a stake in preserving the economic and environmental well-being of the area and perceives traffic congestion as a threat to the continued viability of the area;
- The business community must perceive a benefit from pooling their resources and acting in concert;
- There must be a supportive public policy environment and sympathetic local government officials;
- The TMA must have an energetic and imaginative staff.

Transportation Management Associations attempt to fill an institutional void that often pervades the fast-growing new generation suburbs. Many of the "megacounties" lack effective local government and a concerned civic establishment-two institutions that articulate public needs and concerns in the more established communities. TMA's act as a surrogate for these traditional institutions, and serve as a spokesman and advocate for the unrepresented and fragmented suburban interests. Entrepreneurial in nature and unhampered by bureaucratic constraints, TMA's offer promise of maturing into an instrument of self-governance well-suited to the realities of contemporary suburbia.

ACTION: Traffic Management Teams

DESCRIPTION: Traffic management teams are groups of officials representing different agencies who meet regularly to discuss, plan, and implement strategies for improving traffic flow and handling incidents in a metropolitan area. Such teams typically include state, county and city public safety, engineering and law enforcement. In larger cities, transit agencies and major employers are usually included as well. The focus of such an effort is usually on a corridor or subarea.

States and localities have found the teams to be most successful when they meet regularly, when members are of a stature which allows them to speak for their agencies, when consensus is the basis for decisions and when the chairman has the authority and willingness to set meeting agendas and follow-through to insure agreed-upon actions are taken.

Teams usually focus on planning to avoid problems which can be caused by the following events:

- Accidents
- Special Events
- Weather
- Construction Projects
- Maintenance Operations

BENEFITS/COSTS: The costs of implementing this action are mostly associated with the time of key employees to participate in team meetings. Benefits can be substantial. A study in Texas credited teams with increasing main lane speeds by 9 mph, cutting accidents by 31% and saving 40 seconds per mile for transit buses. The benefit-to-cost ratio for the team and carrying out the activities they recommended was estimated at 15-to-l.

IMPLEMENTATION: The success of traffic management teams depends on having all the relevant agencies participating. Such participation is usually based on some form of interagency agreement or memorandum of understanding. The effectiveness of this effort also relies on the establishment of clear lines of communication and authority so that recommended actions are acted on by responsible agencies. This usually means that the representatives on the team should act with the authority of the agency head, which requires top management commitment to the team concept.

ACTION: Regional Traffic Management

DESCRIPTION: Similar in concept to traffic management teams, regional traffic management consists of transportation and enforcement agencies working together to monitor system operations, respond to incidents, and provide information to motorists that they can use to change routes to avoid congestion. Such an approach requires some form of regional traffic surveillance (e.g., helicopter reports or video cameras at key locations), a central information processing and dispatching location, and a means to convey information to motorists (e.g., radio stations or variable message boards). The technical aspects of such an approach were discussed in Chapter 3 under, ' 'Integrated Freeway and Arterial Network Surveillance and Control."

BENEFITS/COSTS: See Chapter 3.

IMPLEMENTATION: The institutional and funding component of regional traffic management can be quite complex. Cooperative arrangements regarding personnel, funding and lines of authority need to be worked out. Most often this is accomplished through a memorandum of understanding or some other interagency agreement. In some cases, such as TRANSCOM in New York, a separate entity is created and given responsibility for regional traffic management. The creation of a new organization to carry out this function usually requires the development of a careful implementation strategy which focuses on clear lines of responsibility among the participating agencies.

ACTION: Human Resource Development

DESCRIPTION: By 1995, one-third of the transportation professionals currently working will have retired. This high turnover rate provides agencies and professionals with new challenges. Agencies at the state and local level will need to explore initiatives in the following areas:

training-as top managers retire, mid-level professionals will need to be trained for management responsibilities.

shift in skills needed-the change in program emphasis from construction to rehabilitation and maintenance means agencies will need to seek professionals with a different blend of skills than those hired in the post-war construction boom.

upgrade computer use-tougher design challenges in urban and suburban areas and the increasing flexibility of computer applications will require agencies to move towards more reliance on computer and computer skills.

additional use of consultants - many agencies are likely to explore the use of consultants for selected tasks like design, project management and special studies.

BENEFITS/COSTS: Having qualified, well-educated transportation professionals will greatly benefit local officials when technical analysis is necessary for determining the most appropriate course of action. Improved decision-making is the major benefit of this technical expertise. The costs associated with human resource development varies depending on the situation faced by a particular organization and the types of strategies adopted.

IMPLEMENTATION: A 1984 conference on transportation education and training identified the following institutional barriers to the recruitment, development, and effective utilization of human resources in transportation [Ref. 1]:

Salary Structure: The salaries of transportation professionals are well below those in other fields.

- Diminishing Public Service Ethic: Lower salaries were often compensated with the knowledge that professionals were contributing to society and were gaining valuable experience. Institutions must work to rekindle this ethic.

Rigid Hiring and Promotion Practices: Hiring and promotion practices in transportation agencies are often outmoded. An overhaul of these practices is necessary to provide opportunity for younger professionals.

Underutilization of Women and Minorities: A large portion of the future labor force will consist of women and minorities. Appropriate programs need to be developed to foster more participation by women and minorities in the profession.

Undervalued Professional ***Development:*** Organizations should encourage and support employee efforts to obtain training or advanced educational degrees.

References:

1. Transportation Research Board, "Transportation Education and Training: Meeting the Challenge," Special Report 210, Washington D. C., 1984

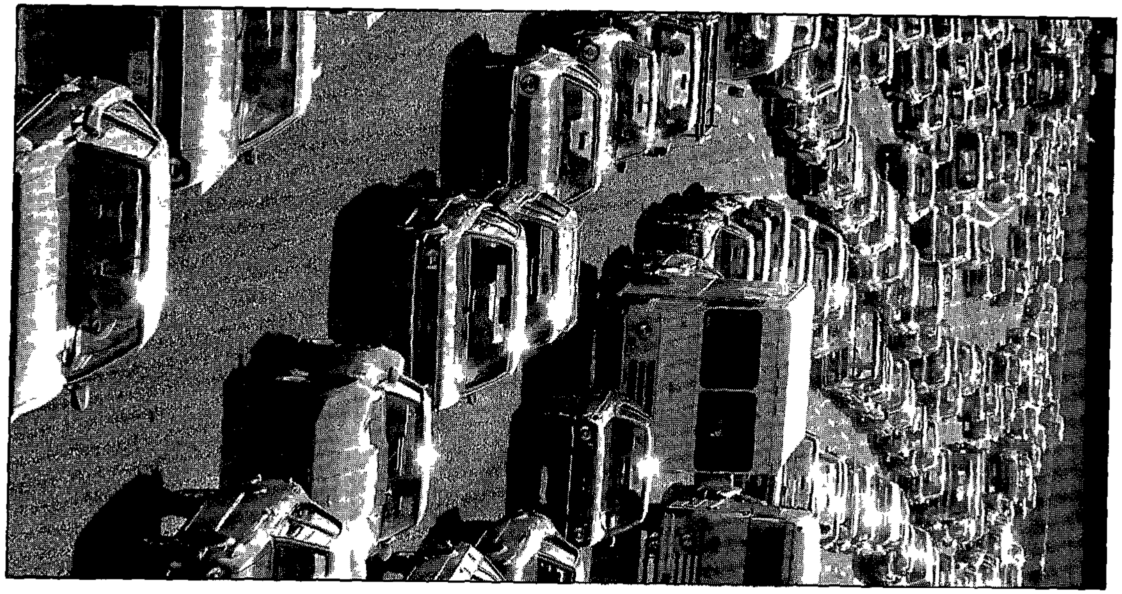


Photo courtesy of Institute of Transportotlon Studies, Universlty of California, Berkeley

8 Summary of the Tools in the Toolbox

Chapters 3 through 7 provided descriptions of the "tools" that are available to local officials for dealing with regional and local congestion problems. The important characteristics of these tools are summarized in the matrix shown in Table 8.1. It should be emphasized that this matrix is only a summary and that more specific information on each technique is available in the respective chapters. One of the key issues facing local officials and transportation professionals is combining the congestion reduction actions into overall strategies and/or programs when the congestion problems facing a community or region require such an approach. Many of the actions in Table 8.1 act to complement each other when applied in a strategic manner; others, however, might work against the desired objective when combined with others. Little or no research has been undertaken on the more global issues surrounding the "packaging" of congestion reduction actions (for an example, see Ref. 1). As shown in Figure 8-1, however, one of the real challenges (and creative aspects of dealing with the congestion problem) is developing a combination of actions that help solve some of the more immediate congestion problems on the transportation system, as well as position the community to deal with the congestion problems of the future.

Table 8-1 summarizes the information presented in the ***Toolbox*** on the impact of each congestion-reduction action. Some attention should be paid to how the costs and benefits of each action are defined. The literature and experience with many of these actions are quite sketchy. In many cases, there is little or no sophisticated analysis of the total costs or real benefits of implementing certain actions. In particular, many studies often emphasize governmental or public costs, while private-sector costs or the degree of intrusiveness on individuals and firms regarding freedom of choice, property rights, and personal mobility are ignored.

The information in Table 8-1 is a summary of the descriptions found in the ***Toolbox*** and thus reflects the state of knowledge on congestion-reduction actions. This information therefore is also quite limited, especially relating to costs and benefits. The quantified benefits of most actions are usually measured in terms of time savings, accident reductions, and other monetary measures of improvement to users and non-users of the transportation system. However, the important decisions relating to tradeoffs and the selection of one set of actions over another must be based on the criteria established by the decision-making authority, which will often include many non-quantifiable impacts. The relationship between the impacts of congestion-reduction actions and what is really important to local officials in the decision-making process is very much dependent on the local situation. This ***Toolbox*** provides information that can be useful in making these local judgments.

References:

1. Roberta Remak and Sandra Rosenbloom, ***Implementing Packages of Congestion-Reducing Techniques,*** National Cooperative Research Program Report 205, Transportation Research Board, Washington DC., June 1979.

Table 8.1-Summary of Tools for Alleviating Traffic Congestion

Congestion Reduction Tool	Impact	cost	Implementation
Freeway Incident Management Systems	Could reduce congestion on about 30 percent of an urban freeway system; could reduce incident duration by an average of 10 minutes; Benefit/Cost of 4:l	$1 million to design and construct; $100,000 maintenance	Long timeframe to implement; requires multiagency approach
Freeway and . Arterial Surveillance and Control	Similar to freeway incident management systems, only over wider geographic area	Expensive; few systems in existence today	Multiagency effort required; public education needed
Motorist Information Systems	Significant reductions in delay on specific facilities	Can be designed for low cost	Long timeframe required; Outreach needed to local officials and media.
Ramp Metering	Highway speeds increased by 24 percent; volumes increased from 12 percent to 40 percent; and 20 to 58 percent reduction in accidents	Depending on type of system, can be low to moderate cost	Long timeframe; need detailed planning effort to avoid local area problems
Add Lanes Without Widening	Significant increases in capacity possible; Benefit/Cost of 7:1.	About $1.3 million per mile for design and construction; $12,000 per year for maintenance	Requires joint effort with enforcement agencies; need public education effort
High Occupancy Vehicle Lanes	Potentially significant increases in person-moving capacity; reduced vehicle miles traveled by 5 percent, and travel times by 6 percent; Benefit/Cost of 6:l	Varies by type; taking an existing lane can be low cost; providing new lanes may cost up to $5 million per mile	Extensive planning required; multiagency cooperation; need public education and marketing campaign
Super Street Arterials	Could increase capacity by 50 to 70 percent	Very expensive; possibly $4 to $5 million per mile	Long timeframe required; possible controversy about land takings and access to arterial
Traffic Signal Improvements	From 8 percent to 25 percent improvement in travel time; Benefit/Cost of 10:1	Low cost; approximately $3,000 per signal update	Requires strong traffic engineering expertise
Intersection Improvements	Varies by level of improvement	Minimal	Need to follow engineering principles
Turn Prohibitions	Reduction of accidents from 38 to 52 percent	Minimal	Often requires outreach to abutters
One-Way Streets	Reduces intersection delays; Redistributes traffic; simplifies signal timing; increases road and pedestrian safety.	Minimal	Need to follow engineering principles; public outreach required
Reversible Traffic Lanes	Substantial increase in capacity; Could produce operational problems	Minimal, although operating costs are required	Enforcement agencies need to be involved in the planning and operations stages
Improved Traffic Control Devices	High Benefit/Cost ratio; substantial benefit in channelizing traffic	Minimal	Need to follow engineering principles; Long-term maintenance strategy required

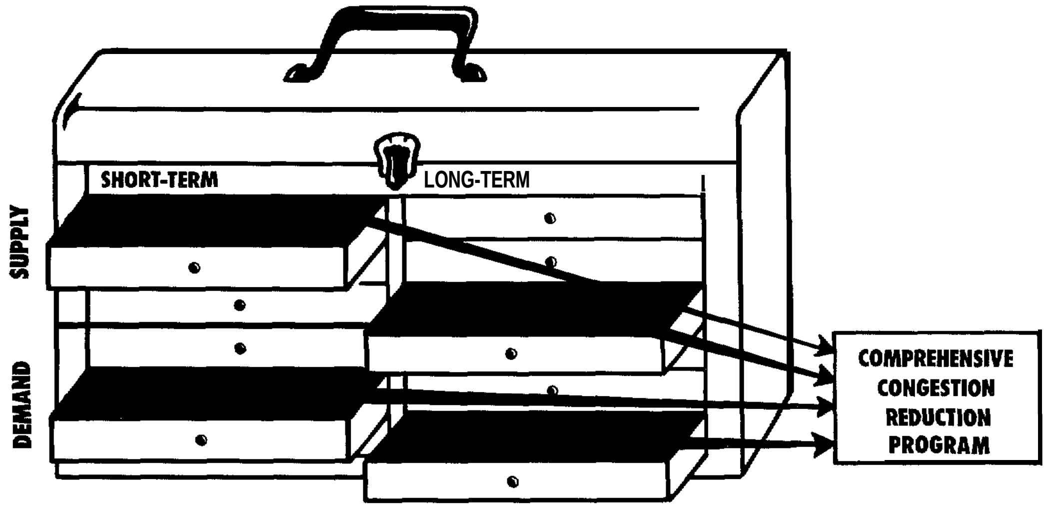
Table 8.1. continued.

Congestion Reduction Tool	Impact	Cost	Implementation
Parking Management	Reduces single occupant driving for specific sites	Additional costs to drivers of single occupant cars	Several characteristics of the site and of the travel behavior need to be considered
Goods Movement Management	Reduces congestion on specific roads; reduces truck-related accidents	Minimal	Needs regulatory or legislative authority; outreach with trucking and business community needed
Arterial Access Management	Reduces vehicle delays and accidents; Impacts mainly over long-term	Minimal	Politically very controversial; Planning studies that justify such a program are needed
High Occupancy Vehicle Lanes on Arterials	Increases person-carrying capacity of arterial; could defer need to widen road; reduces travel time	Varies by type of facility used	Multiagency effort needed; public outreach critical
Enforcement	Substantial benefits can accrue for successful project implementation	Costs can be significant in the early stages of implementation	Advanced plating is essential for success; enforcement agencies need to be involved in the planning process
New Highways	Significant increase of capacity possible; does have long run development impacts; can have environmental impacts	Costs vary by type of highway constructed; in dense urban areas can be very expensive	Can be controversial, especially if environmental impacts; Finance a key issue
Access Control and Management	Reduces accident rates; improves traffic flow; can save future dollars by preserving highway capacity	Gould be substantial if land takings required	Needs engineering specifications; public outreach effort to educate abutters
Geometric Design	Proper design will increase mobility, reduce congestion and right-of-way costs, increase traffic flow, improve safety, and provide better aesthetics	Costs vary by type of design	Design principles need to be adhered to
Reconstruction	Can have dramatic effect on traflic flow and safety	Costs can vary by type of strategy	Careful coordination between design and construction requited
Traffic Management During Reconstruction	Significant reductions in motorist delays possible, some diversions to other routes and modes likely	Costs can be substantial; Enforcement and transit costs can be important	Requires thorough planning and public education; Public and media outreach critical
Fixed Guideway Transit Construction	Can move large numbers of riders; Tmnsitways carry three times volume of freeway lane; can influence development patterns	Costs for construction are substantial, transitways can be less costly	Implementation for all transit options relates to land use and density conditions, urban form, extent of highway availability, extent of transit service availability, difference in travel times between modes, parking costs and availability, transit price, service reliability, site design, perceived safety of service
Fixed Route and Express Bus Services	Provides flexible service to large areas; service can respond to changing markets; can provide high levels of service	Costs will vary by type of service provided; can be very cost effective	
Paratransit Services	Reduces per trip cost; programs can be established quickly; need coordination	First-year cost between $50,000 to $150,000	

Table 8.1. continued.

Congestion Reduction Tool	Impact	Cost	Implementation
Land Use Policies To Improve Transit Access	Provides higher ridership potential; lower transit costs; reduced parking needs, reduced highway demand	Additional costs for developer	Requites close coordination between transit and development community
Site Design Criteria To Increase Transit Use	Similar to above	Similar to above	Set criteria need to be developed; coordination between professional community, developers, and transit agency needed
Transit-Oriented Parking Strategies	More efficient use of land; reduced road and maintenance costs	Cost savings per parking space range from $1,000 to **$15,000**	Parking policies need to be reviewed with transit access in mind
Growth Management	Deals with potential of future congestion; better decisions can be made regarding highway investment	Some administrative costs possible	Can be very controversial; Requires public information and outreach; needs to involve developers and business community
Road Pricing	Substantial reductions in congestion possible	Administrative costs required; installation costs	Can be very controversial; Requires extensive education campaign
Auto Restricted Zones	Can have major impact on area's economic activities; can impact travel behavior	Design costs critical as are enforcement and marketing costs	Important to work with business community
Parking Management	Control of parking can have significant impacts on travel behavior	Depend on strategies chosen	Can be controversial; Needs strong outreach effort
Demand Management Agreements	Can reduce trips generated at specific sites; however, not an areawide solution strategy	Costs associated with administrative oversight and negotiations	Requires bargaining skills and professional staff
Alternative Work Hours	Can reduce peak congestion at local sites	Administrative costs are involved	Criteria need to be established to determine when appropriate
Trip Reduction Ordinances	Ridesharing and transit trips can increase; trips by auto reduced	Same as Demand Management Agreements	Important issues include: extent of coverage, flexibility of means, enforcement, and oversight

Figure 8-1


SHORT-TERM
LONG-TERM
SUPPLY
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COMPREHENSIVE CONGESTION REDUCTION PROGRAM

Notes

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